THE COMPLEAT

Modern Navigator's Tutor:

OR, A

TREATISE

Of the Whole ART of

NAVIGATION

In its THEORY and PRACTICE, &c.

THE COMPLEAT

Modern Navigator's Tutor:

OR, A

TREATISE

OF the Whole ART of

NAVIGATION

In its THEORY and PRACTICE, &c.

The MODERN
Navigator's Compleat Tutor:
OR, A
TREATISE
Of the Whole ART of
NAVIGATION in its THEORY and PRACTICE, CURIOSITY and UTILITY.

CONTAINING

I. *Domeſtick* or *Coaſting* NAVIGATION, Sundry Notes of the Moon's Motions, Calender, Tides, *&c.*

II. THEORETICAL NAVIGATION, by Various Methods, *viz. Geometrical, Logarithmetical, Inſtrumental, Tabular,* and by the *Pen* only (without Tables or Inſtruments.) Together with Practical ASTRONOMY, the Deſcription, Conſtruction, and Uſe of the Plain and *Mercator's* Charts, and other Nautical Inſtruments, *&c.*

III. PRACTICAL NAVIGATION, The Application of the *Theory* to *Practice*; in keeping a Sea-Journal, the working a Day's Log at Sea, in all Caſes of Winds and Weather, making or ſhort'ning Sail, Trying, Hulling, *&c.* And, the manner of making allowance for all known Impediments whatſoever (with Rational Correctſions;) Illuſtrated with full, proper and practical Examples of the ſame. The whole more *amply* and *plainly* demonſtrated, than in any Treatiſe of this kind extant. To which are added,

All Neceſſary Tables, *Nautical* and *Aſtronomical*, for the Mariner's Practice, by Inſpection.

Alſo an APPENDIX,

Touching Pleaſant and Critical Queſtions in *Navigation*; with divers other things both Curious and Uſeful in this Art.

By JOSHUA KELLY, Mariner, and Teacher of the MATHEMATICKS.

LONDON,

Printed for *J. Wilcox*, in *Little Britain*; *B. Macy*, on *Hermitage-Bridge*, *J. Marſton* in *Denmark-ſtreet*, *J. Eade* at King *Edward's Stairs*, and *J. Kelly* in *Broad-ſtreet*, in *Wapping*. MDCC XXIV.

D3-10

Advertiſement,

IN *BROAD-STREET*, WAPPING, near *Wapping-New-Stairs*, are Taught theſe *Mathematical Sciences*,

VIZ.

ARITHMETICK,		DIALLING,	
MERCHANTS ACCTS.		SURVEYING,	
GEOMETRY,		GAUGING,	
TRIGONOMETRY,		GUNNERY,	
NAVIGATION,		FORTIFICATION,	
ASTRONOMY,		ALGEBRA,	

The Uſe of the GLOBES, and all other *Mathematical Inſtruments*; the Projection of the Sphere on any Circle,

By JOSHUA KELLY:

With whom Young Gentlemen, and others, are (well *Boarded*, and) Compleatly and Expeditiouſly Qualify'd (on Reaſonable Terms) for any Buſineſs relating to *ACCOMPTS* and the *MATHEMATICKS*.

H. Lavendish.

BRITISH MUSEUM

To the Honourable

Matthew Martin, Esq;

Member of Parliament for *Colchester*;

Captain *John Haslewood*,

And the rest of the Worshipful

The *Master*, *Wardens*, *Assistants*, and *Elder Brethren* of the *Trinity-House* of *Deptford Stroud*, &c.

GENTLEMEN,

THE Oblig'd Author, with all Submission, devotes the ensuing Treatise to you (as your just Right,) not doubting but by your great Sagacity, and penetrating Judgment in this kind of Learning, you will readily perceive, that my sincere Intention of doing service to the World, hath animated me to publish this Epitome of the *Mari-*

ners

ner's Art, for which, and the Publick Good, you have always been ſo conſpicuouſly zealous; particularly by your encouraging this Noble and Uſeful Science, wherein the Safety, Wealth and Glory of the *Britiſh* Nation are ſo much concern'd. I am well aſſur'd, that no Perſon without your Examination and Approbation, can be admitted to Publick Mathematical Services in the Royal Navy *&c.* and that, bringing all ſuch Perſons to the Scrutiny, as their Merit, ſo your Countenance appears.

THIS Art, *Gentlemen*, I undertake to Teach, and offer to the World, having grown up with me from my Minority, being the reſult of a long Theory, and many Years Experience at Sea, in quality of *Mate*, *Maſter* and *Inſtructer* to the Gentlemen-Volunteers in his Majeſty's Royal Navy, appointed (after a ſtrict Examination) by Your Board; I'm not without hopes of being accepted in this my Addreſs, and preſume therefore to make choice of ſo Honourable a FRATERNITY for my PATRONS; who are deſervedly Famous for your ſuperlative Knowledge in *Maritime Affairs*, and by all juſtly eſteemed the Ableſt Maſters in this Art, as well as the moſt proper Judges of Works of this nature: Your very Names will excite the Young Student in *Navigation* to a diligent Application, when he conſiders your Candor, Generoſity, and propitious Inclination towards all who endeavour

deavour any way to promote or improve by it the true *Engliſh* Intereſt.

THEREFORE, if my Performance herein may but obtain your Approbation, and your Acceptance give it an *Imprimatur*; I ſhall be the leſs concern'd at the carping Cenſures of *Zoilus* and *Momus*, (or any ſuch, who prefer their own private Intereſt to the Publick Good;) and be the more encourag'd to ſpend the reſt-due of my Days in promoting this Famous ART, in which I have already ſpent a great part of the Studies of my paſt Life: And, among the Numbers I have Taught, have, not long ſince, had the Honour of inſtructing ſome of your Sons, Relations, *&c.*

THIS, *Gentlemen*, further emboldens me to caſt my Mite into your Treaſury; which, as a ſmall Pledge of my Eſteem for your Favours, I beg you will be pleaſed to accept.

I ſhall conclude this *Dedication*, with the grateful and pleaſant Reflection all muſt have of the great Honour and Benefits which accrue to the *Britiſh* Dominions by your Wiſe Conduct and Indefatigable Applications, and by your Publick Zeal for the Common-Weal. 'Tis the Courage of ſome of your Honourable Brethren, that has quell'd the Pride of MONSIEUR, removed War from our Doors, and planted the O-

live-

live-Branch in the midſt of *Great-Britain*: 'Tis the Conduct of others, that has tranſported into our Iſland the Wealth of both *Indies*, carry'd away our Superfluities, and brought us home our Conveniencies; making the Pleaſures, Riches and good Things of the whole World common to all Mankind: 'Tis the Vigilance of others, that renders our Sands and Shoals navigable, procuring Sea-Marks, Light-Houſes, *&c.* for the ſafety of Shipping: And 'tis Your Sagacity alſo that procures Able Maſters and Pilots for our Ships of War, and of Merchants, *&c.* And, to name no more, ne'er a Society in *Europe*, Eccleſiaſtical or Civil, can equal your extenſive Charity, in maintaining decently ſuch a Number of poor Seamens Widows, *&c.* Theſe not only raiſe Admiration in all Men, but excite the beſt to pray for you, and the Proſperity of your *Worthy Fraternity*: With whom ſincerely joins,

GENTLEMEN,

Your moſt Obliged, and

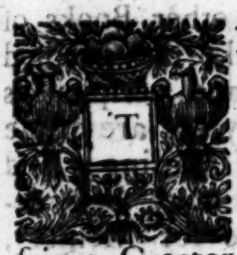
Moſt Obedient Humble Servant,

Joſhua Kelly.

PREFACE,

To all Lovers and Learners of

NAVIGATION.



IS an uncontroverted Maxim, allow'd by all, and beſt known by thoſe of the Noble Tribe of *Zabulon*, That the Art of Navigation, by which Iſlands are enrich'd and preſerv'd in Safety from Foreign Invaſions; the wonderful Works of an Omniſcient Creator, in the wide extended Ocean and remote Nations, are delightfully beheld, *&c.* is a very excellent and neceſſary Art; and that 'tis no mean Accompliſhment, to be capable of conducting a Ship richly laden, round the World. Neither can it be deny'd, that the Riches, Safety, and Glory of *Great Britain*, conſiſt in its Naval Power: (For the more it is improv'd, the more Great, the more Safe and Rich, will theſe Kingdoms be; and on the contrary, the more the Navigation and Naval Power is diminiſh'd or diſcourag'd, theſe Nations will be the more Mean, the more Poor and Inſecure:) This Art not being as yet arriv'd to its *Ne plus ultra*, will admit of further Improvements, till God ſhall permit us to diſcover a certain Method, for finding the Longitude at Sea. I ſhall therefore, in Compliance to Cuſtom, ſay ſomething as Prefatory to the enſuing Trea-

tiſe; and why I undertook the Publication thereof, in an Age that ſo abounds with Books of this nature: But the Difference between them and this will appear obvious (to the Knowing and Impartial Reader,) by comparing 'em together. For beſides that want of a plain and regular Method in THEORY, and the Defect of ſufficient Tables and demonſtrative Examples in the PRACTICE of this Art, in the ſeveral Books of this kind extant; moſt of theſe are either too Voluminous, and tend rather to Diſtract than Inſtruct; and ſo the Learner is deterr'd or diſcourag'd from the Study: Or elſe too abſtruſe and perplex'd, being promiſcuouſly fill'd with unneceſſary Problems, and intermix'd with Things foreign to the Art of Sailing. I have therefore, (for the ſake of thoſe who value the ſolid and ſubſtantial Part of this Science, rather than uſeleſs Speculations,) here omitted nothing that may be of uſe to the Mariner; but made it a general Treatiſe of Navigation, (both for *Curioſity* and *Uſefulneſs*,) to ſupply the Defect of all other Books of this kind: And in endeavouring to make the Method throughout the whole, uniform, plain, and perſpicuous as poſſible, I have given ſuch Caſes only, as are of uſe to the Mariner in the ſeveral kinds of Sailing; and have applied ſuch Examples to each, as may beſt demonſtrate their Operation, be moſt eaſie for Memory, and applicable to Practice. And all the *Rules*, *Projections*, *Analogies*, manner of working and reſolving thoſe Caſes, according to the various Methods inſerted, I hope, are explain'd in a natural Order, in ſhort and clear Terms, to render them eaſie to the underſtanding of the moſt indifferent Capacity. Nor can I conceive there is any thing material omitted, or any thing inſerted ſuperfluous, or which was not neceſſary to make the Body of the Book correſpondent to the Title-Page: Beſides there are ſome Improvements in the *Theory*, and ſuch full and demonſtrative Examples in the *Practice* or Journal-part, that I think I may affirm, have not hitherto been treated of by any; and in ſuch an Experimental Method, as I have taught and practis'd with Succeſs, both at Home, and in Foreign Voyages, for more than Twenty Years, (in the various

various Stations of *Mate, Maſter, Regular Sworn and Warranted Teacher of the Mathematicks*, to the *Gentlemen-Volunteers* in his Majeſty's *Royal Navy.)*

As for the Stile, 'tis plain, and ſuited to the Meridian of Seamen; who undoubtedly will ſearch here for Truth and Uſefulneſs, and not for Rhetorical Eloquence; (Accompliſhments ſeldom courted by the Honeſt Sailor, for they will never help him to a good Land-fall, nor keep his Ship from a Lee-ſhoar.) And for the Rhymes interſpers'd in this Tract, if they ſeem not ſo Poetical as they ought, or I have not kept *Decorum*, I ſhall not oblige my ſelf to anſwer either for the Poet or Poetry; they being inſerted only to make it more taking with the Juvenile ſort of Perſons, who are as much delighted with ſuch, as perhaps the more Learned and Knowing are with better.

I hope it can't reaſonably be expected in a Treatiſe of this bulk, purely deſign'd for Navigation only, that I ſhould have treated of the Uſe of the *Globes*, Doctrine and Projection of the *Sphere*, *Geography*, &c. which indeed are Sciences copious enough for a Treatiſe of themſelves, (if well handled:) And therefore, there being plenty of ſuch in the World, the Reader is referr'd to them.

Thus having laid my Labours before the Courteous Readers, who are moſt likely to receive Profit thereby, at a ſmall Charge; I muſt entreat others to uſe me as they would themſelves be us'd, which is the ſpontaneous Act of every Good Man; and deſire that what *Errata* have crept in, thro' the Printer's means, or my own Overſight, the Reader would paſs over: For neither He, nor I, nor any of the Sons of *Adam*, (nor their Writings,) are infallible; ſince according to the Proverb,

Nemo ſine crimine Vivit.

No Man e'er liv'd (on Earth) nor ever ſhall,
That did all well, and had no Fault at all.

And

And as Mr. *Pope* ſays,

Whoever thinks a Faultleſs Piece to ſee,
Thinks what ne'er was, nor is, nor e'er ſhall be.

Altho' my Deſign here is more intended for Publick Good, than my own Private Intereſt; (for this Age ſeldom tempts the writing in a Mathematical way for Profit;) yet, no doubt, the carping *Momi* may pick ſome Criticiſms out of the Book. To ſuch I ſhall only in Modeſty ſay, 'Tis much eaſier for thoſe captious Readers to carp than amend. This is indeed, a ſcribling Age, that peſters us with many uſeleſs Pieces, where the Authors write out of Spleen, Pride, or for the getting of Money. But ſuch a Subject as this needs no Recommendation, one would think, in ſuch a Nation as this, ſo flouriſhing in Trade and Shipping; yet, no doubt, this Piece will not be equally eſteem'd by all: Thro' Partiality and Self-Intereſt ſome, perhaps, may contemn ſuch Performances: For indeed this Age produce little elſe but Drollery and Ridicule by baffling Wits, who can only canvaſs a Word, or clamour at a Phraſe in an Author. And ſuch *Heroſtratus's*, *Nugator's*, and *Ardelio's*, that would fain almecanthorize themſelves from the Nadyr of *Ignoramus*, to the Zenith of *Non Parallels*, becauſe they cannot get a Name by any eminent Work of their own, ſeek it in the deſtroying that of others: But we muſt let 'em know, it is eaſier to be a Critick than an Author. And if he who would judge impartially of an Undertaking of this nature, would but take the Pains to make himſelf Maſter both of the Theory and Practice of this Art, and then eſſay ſomething of the like Kind, (for Authors ſhould be try'd by their Peers,) we ſhould be rid of thoſe detracting Enemies. I wiſh it were not to be ſaid, that this Noble and Uſeful Art hath of late Days been made Contemptible, by the Number pretending to teach it, that want the neceſſary Qualifications, and have never been in the Practice thereof at Sea; and conſequently the Learner with ſuch, ſpends his Money and Time to very little real Advantage: I ſhall therefore, with Submiſſion to better Judgments, preſume to offer the following Truths,

which

which I've asserted long since to the Publick on the *Royal-Exchange*, viz.

I. That the generality of the Teachers of Navigation, are very much to seek in the Practical and most necessary Parts of this Art.

II. That several are also very imperfect in the *Theory*, and altogether Strangers in the *Practice* of keeping a Sea-Journal; or the working a Day's Log, in all the various Cases of Winds, Weather, making and short'ning Sail, Trying, Hulling, &c.

III. That many of these do not make Teaching their only Business; but are too frequently employ'd in their proper Callings, Trades, Shop-keeping, &c. to the great Hindrance, expence of Money and Time of the Learner; (who generally is under a Necessity of making a speedy Application.)

IV. That it is not the Learning a few *Problems* from such kind of (negligent) Half-Teachers; but a thorough Knowledge of both the *Theory* and *Practice*, that will make a Man a compleat Artist. And all know, that this Art is not a Matter of so trifling Knowledge, and so indifferent whether it be thorougly understood or not; but 'tis a Science of the utmost Importance, wherein the Lives and Estates, the Good of both the Publick and Private are in danger, from a small Mistake committed therein; and therefore, should be taught or learn'd to the utmost Perfection: And by Consequence, Honesty, Fidelity, due and constant Care and Attendance, with a sufficient Skill in both the *Theory* and *Practice*, are, or ought to be, inseparable Qualifications in an Able Teacher.

Si reprehendi fers ægrè, reprehendenda ne feceris.

It would be well that these things were inspected by the Learned Judges of this kind of Learning; and that such Persons would observe, what was inculcated by the Poets, when they feign, that their gods do content themselves with-

within the Compaſs each of his own Sphere; *Mars* medleth with *War*, *Minerva* with *Arts*, *Mercury* with *Eloquence*, *Jupiter* with *Heaven*, *Pluto* with *Hell*, *Cupid* with *Love*, *Neptune* with the *Sea*: And conſequently, this Science more immediately pertains to the *Mariner* to be Maſter of; and not to ſuch Land-Navigators, who have learn'd to ſwim without going into the Water; and to ſail on a Slate and Paper only. I'm apt to believe, theſe Perſons would have but few Pupils, were they not daily to frequent Publick-Houſes, and by Oſtentation, inſinuate and boaſt of their great Ability this way among *Ignoramus*'s: And, as a late Author obſerves, many that are about to learn, apply to any one that will teach cheapeſt; not conſidering, that the very Reaſon why they do ſo, is commonly the want of ſufficient Ability to recommend themſelves any other way: And then it is too common, as ſoon as One has been taught, (and perhaps but a Green-Head, before his Underſtanding be well ripe,) he ſhall undertake to teach another; and that other a Third, and ſo on. Now if we ſuppoſe the Beſt, *viz.* That the firſt Perſon was well Taught; yet it muſt be conſider'd, that tho' he that undertakes to teach an Art, muſt be Maſter of it; (or according to the Poet,

He that hath Art, and can impart
That Art, with Art, is Maſter of his Art:)

Yet it muſt be own'd, 'tis not every one that is Maſter of an Art, that is equally qualify'd to teach it; ſince many times, it is much more difficult to communicate an Art to another, than it is to attain it our ſelves; and the Reaſon is obvious, becauſe firſt, this muſt be gain'd by much Practice in Teaching, and having a thorough Knowledge of the Theory: That the Tutor may be able to give different Explanations of a *Propoſition*; that if one does not ſuit with his Pupil's Underſtanding, another may. Secondly, the Capacities and Tempers he has to do with, may be as various as the Number of his Scholars: (Theſe, and many things more might be nam'd.) So that his firſt Care muſt be a ſuitable and plain Method; and prudently to make a right Judgment of their ſeveral Capacities and Tempers,

when

when he deals out Inſtructions to them: For 'tis a known Maxim, that even every good Scholar is not equally qualify'd for Teaching. I would not be thought Magiſterial or Satyrical in theſe Caſes, in detecting ſome Mens Practices: I'm perſwaded the qualify'd Teachers of this Art, (whoſe Number is but ſmall in this great Metropolis,) will acquieſce with me; and ſhall only ſay, if the World is reſolv'd to favour ſuch Impoſitions, in Matters of this Conſequence, 'tis their own Choice, not want of Diſcovery in me. I ſhall here therefore beg leave to add the Words of the Great *Cicero*, viz. "Every Thought and Motion of "the Mind, ought to be employ'd either in conſulting of "honeſt Things, and ſuch as may lead to a good and "happy Life; or in the Study of Arts and Sciences, and "the way to gain Knowledge: For we are all drawn, or "as it were, led by the Hand to a Deſire of getting "Knowledge, and bettering our Underſtanding; wherein "to excel is accounted an excellent thing; but to ſtray from, "be ignorant of, or eaſily deceiv'd, not only by others, "but alſo by our ſelves, is a great ſtain to Reputation.

To conlude therefore: If this Fruit of my Labour find good Acceptance in the World, I ſhall think my Pains well beſtow'd; and if Encouragement be given, ſhall publiſh ſome Treatiſes I've writ on all the Branches of the Mathematicks, plainly demonſtrated to the meaneſt Capacities; and which ſhould have been offer'd to the Publick before this, but the Importunity of divers able Navigators, hath oblig'd me to delay theſe, till the Publication of this Book. And that my Learner may reap the Benefit hereby intended him; and that Succeſs and Proſperity may attend his Lawful Study and Undertakings, is the Deſire of him that wiſheth the young Student's Proficiency, and the Progreſs of all uſeful Arts.

From my School in *Broad-ſtreet, Wapping*, May 1. 1724.

J. Kelly.

PREFACE

THE

CONTENTS.

PART I. CHAP. I.

Domeſtick or Coaſting Navigation.

§. I. Præm. II. *OF the Common Notes of the Calender*, viz. *To find the Sun's Circle, Prime, Epact, Moon's Age and Southing, and time of Full Sea at any Place.* Page 1

III. *To find the Moon's ſhining, how many Signs and Degrees ſhe hath departed from the Sun, ſince her laſt Conjunction with him; and her Place in the Zodiack at any Time.* 5

IV. *Of a Year, and kinds of Months; with an Eſſay on the Emendation of the Old; or* Julian *Account.* 8

V. *To find when it's Biſſextile, or Leap-Year; and what's the Dominical Letter.* 14

VI. *To find the Dominicals, Sun's Circle, Prime, Epact, Moveable Feaſts, Eclipſes, Moon's Age, Moon's Southing, her Shining; Moon's Diſtance from the Sun; Moon's Motion, her Riſing and Setting, and Time of High Water at any Place, by Inſpection in our Tables.* 15

VII. *To find how it flows Full and Change of the Moon, at any Place; and to collect the Aſpects of the Sun and Moon throughout the Year.* 16

PART II. CHAP. I.

Theoretical Navigation.

§. I. *The neceſſary Geometrical Problems.* 20

The CONTENTS.

II. *The Elements or Principles of Plain or Rectilinear Trigonometry.* 27
III. *General Definitions, Primary Rules and Problems in Navigation.* 32
IV. *Of the Nature, Conſtruction, and Uſe of the Plain Sea-Chart, both General and Particular.* 41

CHAP. II. Plain Sailing.

Method I. *The Caſes of Plain Sailing, Projected, Geometrical, and wrought by the Logarithms and* Gunter's *Scale, with the Uſe of each Caſe in the Practice of Navigation.* 47
Meth. II. *By the Traverſe Tables.* 56
Meth. III. *By Natural Arithmetick, and given Numbers with the Square Root.* 59
Method IV. *By Natural Arithmetick, and another Set of given Numbers.* 61
Meth. V. *By the Pen only, without any Tables or Inſtruments.* 67
Meth. VI. *By finding a Natural Radius, which ſhall produce the ſame Anſwer by Natural Arithmetick, that the Radius or Sine of* 90°. *produces in a Sinical Proportion.* 79

CHAP. III.

§. I. *Plain Sailing Traverſe, (by all or any of the aboveſaid Methods ;) in uſeful and practical Examples ; and the Solution of a General One, of a Ship and Port.* 78
II. *Of the Conſtruction, Utility, Verity, Excellency, and Uſe of (Mr.* Wright's, *commonly called) the* Mercator's *Chart, both in General and Particular ; with the making a Table of Meridional Parts.* 86
III. *Of* Mercator's *(or rather* Wright's*) Sailing ; with the Solution of a* Mercator's *Traverſe, of a Ship and Port.* 102
IV. *Parallel Sailing, with great Variety of Projections therein.* 119

CHAP. IV.

§. I. *Of Sailing by the Middle Latitude, a Method nearly agreeing with* Mercator's *Sailing ; with variety of Projections therein.* 129
II. *Of Oblique Plain Sailing.* 143

III. *Of*

The CONTENTS.

III. *Of turning to Windward, or the Method of gaining a Port in the ſhorteſt Time, with a contrary or ſcant Wind.* 151
IV. *Of Currents, their nature of Agitation, how to make Trial for the Diſcovery of them, and to find the Ship's true Motion in them, either in ſailing by, large, or turning to Windward.* 155

CHAP. V. Astronomy.

§. I. *Of Aſtronomical Definitions, and Practical Problems relating to the Courſe and Motion of the Sun and fixed Stars, uſeful in Navigation.* 170
II. *The Deſcription and Uſe of the Azimuth (or Amplitude) Compaſs.* 199
III. *To find the Variation of the Compaſs, both Geometrical and Arithmetical, by an Amplitude or Azimuth.* 203
IV. *To find the Variation by the North Star; and at Noon, by the Shadow of the Sun.* 207
V. *To find the Variation by two equal Altitudes of the Sun, taken before or after Noon.* 209
VI. *Of the Nature of a Celeſtial Obſervation; the Deſcription and Uſe of the Sea-Quadrant, Almicanthar-Staff, Croſs-Staff.* 211
VII. *To work a Celeſtial Obſervation.* 218
VIII. *A Collection of remarkable Stars, and the Time when they come to the Meridian, throughout the Year.* 225
IX. *To find the Latitude at Sea by Obſervation of the Stars.* 229
X. *The Deſcription and uſe of the Nocturnal.* 233

CHAP. VI.

§. 1. *To find the time of the riſing and ſetting of the fixed Stars, their Amplitudes, Azimuths, Hour of the Night, &c.* 237
II. *The Practical Queſtions in Aſtronomy, ſolv'd by Inſpection in Tables.* 241

PART III. Practical Navigation.

The Application of the *Theory* to the *Practice*, in keeping a Sea-Journal, and Working a Day's Log in all Caſes; the Ship ſailing By or Large, in all Winds and Weather, ma-

king or short'ning sail; and to make Allowances for Variation, Growth of Sea, Lee-way, and Currents; and the Method of correcting a Dead-Reckoning by a Celestial Observation, &c.

CHAP. I.

§. I. *What is to be observ'd at the Beginning of a Voyage.* 247
II. *Of the Log-line and Half-Minute Glass.* 248
III. *To find at Sea if your Quadrant or Cross-Staff is faulty or not, and to allow for it accordingly.*
IV. *What must be observ'd in Sailing near the Shoar, and approaching near a Port.* ibid.
V. *Of the Instruments to be in readiness for the Mariner's Practice; the Form of the Log-board, the manner of heaving the Log, and marking the Log-board,* &c. 252

CHAP. II.

§. I. *To work any Day's-Log, the Ship sailing Large, or before the Wind.* 256
II. *General Rules for correcting, by an Observation plainly demonstrated.* 265
III. *To work a Day's Log, or to keep an Account of a Ship's Way upon a Wind, exemplify'd in all Weathers; the Top-sails set, under her Courses, Try under a Main-sail and Mizen, Try under a Main-sail only, Try under a Mizen only; lastly, Trying or Hulling,* viz. *with all Sails furl'd.* 272
IV. *Another Example of a Day's Work, when the Log is hove but every two Hours; with a second Correction by an Observation.* 283
V. *The Form of a Journal, according to the Merchant's or Naval Method, wherein is transferr'd or posted, the foregoing Days Works from the Land, together with all remarkable Occurrences.* 290
VI. *An Instrument for the Pocket, called the Nautical-Medal, whereby may be wrought a Day's Log by the Pen, without burthen to the Memory, with an Example of the Use of the same.* 294

POST-

The CONTENTS.

POSTSCRIPT.

VII. Laſtly, *Multiplication, Diviſion, the Rule of Three, Extraction of the Square and Cube-Roots, perform'd with great (facility or) eaſe by Logarithms.* 302

TABLES.

N°. I. *A Table of the Dominical Letters, Cycle of the Sun, Prime, Epact, Moveable Feaſts, and Eclipſes for 16 Years.* Page 1

II. *A Table of the Moon's ſhining, Diſtance from the Sun, and her Motion for every Day and Hour of her Age.* 4

III. *A Table ſhewing the Moon's Changing for 8 Years, together with a Table of her Southing, Riſing and Setting.* 5

IV. *A Table of the Angles which every Point of the Compaſs maketh with the Meridian; alſo the Time anſwering each Point.* 7

V. *A General Tide-Table.* 8

VI. *A Table of Logarithm-Numbers, from 1 to 1020.* 10

VII. *A Table of Natural and alſo Logarithmetick Sines and Tangents, to every Degree of the Quadrant, and Point and Quarter-point of the Compaſs.* 20

VIII. *A Table of Squares with their reſpective Roots.* 24

IX. *A Traverſe Table in Points and Quarters.* 26

X. *A Traverſe Table in Degrees.* 30

XI. *A Table ſhewing the Diſtance Run, Difference of Latitude or Departure, for every Point, ½ or ¼ Point of the Compaſs; with a Table ſhewing the Reduction of Minutes into Decimals, and the contrary.* 41

XII. *A Table of Natural Secants.* 42

XIII. *A Table of Meridional Parts.* 43

XIV. *A Table of the Miles anſwering a Degree of Longitude, at every Degree of Latitude,* 51

XV. *Alſo a Table ſhewing the Diſtance and Departure for every Point and Quarter-Point of the Compaſs; the Diff. Latitude being 1 Degree or 60 Mile.* ibid.

XVI. *A general Table of Gunnery.* 52

ASTRO-

The CONTENTS.

ASTRONOMICAL TABLES.

XVII. *A Table of the Sun's Declination.* 54

XVIII. *A Table to reduce the Sun's Declination to any other Meridian that of London,* 62

XIX. *Alſo a Table of the Refractions of the Sun, Moon and Stars.* ibid.

XX. *A Table of the Sun's Riſing and Setting, from the Equinoctial to the Latitude of 60 Degrees North or South.* 64

XXI. *A Table ſhewing the longeſt Day, in every Degree of Latitude.* 74

XXII. *A Table of the Sun's Amplitude Eaſt or Weſt, from the Equinoctial to 60 Degrees of Latitude, either North or South.* 76

XXIII. *A Table of the Sun's Right Aſcenſion.* 86

XXIV. *A Table ſhewing the Semi-diurnal Arks, Seaſons for obſerving, Right Aſcenſion, and Declination of ſome Principal fixed Stars.* 88

XXV. *A large and correct Table of the Latitude and Longitude of Places.* 89

XXVI. *A Table of the Latitudes, Bearing and Diſtance, Difference of Longitudes, and Difference of Meridians from London, of ſeveral eminent Cities and Towns.* 101

XXVII. *To find the Meridian Altitude, Zenith Diſtance, (conſequently the Latitude, with the Sun's Declination given) with two Sticks only, if you are depriv'd of your Fore-ſtaff or Quadrant.)* 102

XXVIII. *To find the Sun's greateſt Declination.* 103

XXIX. *The Axioms or Theorems in Plain Trigonometry demonſtrated.* 104

XXX. *A Table of the Soundings coming into the Britiſh Channel; the Quality of the Ground brought up by the Tallow on the Lead, with the Bearings and Diſtance of the* Lizard, Scilly, *&c.* 106

APPENDIX.

A Collection of ſundry Pleaſant and Critical Queſtions in Navigation. Page 1

To meaſure Bales and Caſes, and to find their Tunnage. 14

To find the Burthen of any Ship. 17

To Gauge any Cask. 18

To

The CONTENTS.

To find how much Powder is sufficient both for Action and Proof of any Piece of Ordnance. 21
To make any Dial to any Plane. 22
Of the most rational Ways propos'd to find the Longitude at Sea by Observation. 23
An Essay to find the Annual Variation of the Needle, at all Times, all Seasons, and all Places or Latitudes. 37
A Ship's Tackling described. 43
The Young Seaman's Dictionary, or an Explication of the most usual Sea-Terms, in an Alphabetical Order. 45
To work a Ship at Sea, in the proper Sea-Phrases, and to manage her in Fight: A lively Description of a Ship of War, engaging her Enemy, taking her Prize, &c. 51
Of the Sea or Ocean. 61
Of the Nature and Qualities of the principal Winds. 62
Of the various Colours of the Sea. 65
Natural Prognosticks of the Weather, deduc'd from Philosophical Aphorisms, and frequent Experience of Judicious Persons. 66
Answers to the Questions in Navigation, propos'd at the Beginning of this Appendix. 69

An

An Explanation of the Symbols or Characters us
in this Treatiſe (for brevity ſake.)

+	Signifies	More, or add; as, A + B, is A more B.
−		Leſs, or ſubſtract; as, A − B, is A leſs B.
X		In, or multiply; as A X B, is A multiply'd by B
÷		By, or divide; as A ÷ B, is A divided by B
.. :: ..		Rule of Three; as A .. B :: C .. D, *i.e.* or Di- rect Proportion; as A is to B, ſo is C to D
S.		Sine.
S.C.		Sine Complement.
T.		Tangent.
T.C.		Tangent Complement.
Sec.		Secant.
Sec.C.		Secant Complement.
R.		Radius or Sine of 90 Degrees.
Z.		Sum.
x.		Difference.
=		Equality; as A = B, is, A is equal to B.
$\sqrt{2}$		Radicality, or Square Root; as, $\sqrt{2}$) 144 (12. *i.e.* the Square Root of 144 is 12.
∠		Angle.

THE

PROEME.

Of the Antiquity, Progress and Utility of NAVIGATION.

The Tyrians, *they say, the* Art *did find,*
To make Ships travel with the Wind.

IS uncertain in what Age of the World Men first began to think of Travelling by Sea, but as to the first Invention of this excellent Art, it can be ascribed to none other but GOD himself, who first taught the *Hebrews*, his chosen People, (and not the *Egyptians* and *Phœnicians*, as some have falsly imagined) for we read in the 6th Chapter of *Genesis*, verse 14. *That* Noah, (by GOD's Command) *built an* Ark *to preserve*

ſerve himſelf, and other living Creatures with him, from the Deluge of Waters; for before this we do not read of any Skill in Navigation; yet are we certain, this *Art* was very ancient, for we read in *Geneſis*, Chap. 1. That the terraqueous Globe of the World was no ſooner created, but Man had Dominion over the Fiſh of the Sea, *Jure Divino*, which could not be well without *Naval Architecture*, and ſome *Skill* in the *Art* of *Navigation*. 'Tis now more than 4000 Years ago ſince the aforenamed *Noah*, that *Totius Orbis Thalaſſiarchus*, or High Admiral of the whole World, with his Ship, called, The *Ark* of *Gopher*, laden with a Cargo of the whole Univerſe, after near a ſix Months Voyage, arrived ſafely at *Ararat*, his Port of Diſcharge in *Armenia*, which was re-peopled by his Progeny *Shem*, *Ham*, and *Japhet*; and Hiſtory acquaints us that *Europe* was, at firſt, peopled upon all the Sea Coaſts from the *Eaſt*; and, accordingly, *Moſes*, in deſcribing the firſt Peopling of the World, calls *Europe* by the Name of the Iſles of the *Gentiles*, implying that the *Jews* accounted its ſeveral Regions acceſſible to them only by Water, after the Manner of Iſlands. The ſeveral Colonies ſent in the firſt Ages by the *Egyptians*, *Phœnicians*, and *Greeks*, through the *Mediterranean*, are farther Teſtimonies of this Thing; *Jacob*, in his Bleſſing of *Zabulon*, mentions Ships upon the *Mediterranean*, as a Thing well known in his Days. The ancient *Phœnicians* traded as Merchants, and are celebrated in Scripture for it. *Ezek.* 27. And when *Solomon* built a Navy upon the *Red-Sea*, he uſed *Phœnician* Pilots; but before the Flood, we do not read of any Ships, Boats, or *Skill* in *Navigation*, and for this we have many Reaſons and Conjectures that there were none. *Firſt*, Becauſe in thoſe Times there was greater Need of Cities than Ships, becauſe Cities are not made for Ships, but Ships for Cities, for their Trade and Defence. *Secondly*, Becauſe in thoſe Days little Commodity could be reaped from other Countries, they lying then rude and uninhabited. *Thirdly*,

Thirdly, Some would have it that God would not reveal this to the old Worldlings, becauſe being ready to periſh in the Deluge, no Man might have Means to eſcape; which, doubtleſs, they would have attempted, had Navigation, (or the Uſe of Boats or Ships) been known. Tis probable, therefore, that the Knowledge of Ships, (and, conſequently, of Navigation) was diſcovered to *Noah* at the Time of the Deluge; whoſe *Ark*, afterwards reſting upon the Mountain of *Ararat*, gave a Precedent to other Nations, near bordering, in what Nature Ships were to be formed: From whence it came to paſs, that the firſt to whom this Skill was derived, next to the *Hebrews*, were the *Tyrians* and *Phœnicians*; Nations, as well for the Commodity of the Place as other Inducements, inclining to Navigation; for *Tyre* being a principal Market Town of *Phœnicia*, bordering upon the Sea; and this Knowledge, being derived from them to other Nations, might give Occaſion to *Stratus* and *Strabo* to conjecture that they were the firſt Inventors of it. From the *Phœnicians* it was deriv'd to the *Egyptians*, tho' but in a rude and unpoliſh'd Manner; the firſt Veſſels being not much unlike thoſe *Canoes* we find ſtill uſed by the *Negroes* and *Indians*, and *Pliny* tells us that they began to ſail in a certain Veſſel called *Ratis*, (which now ſignifies a Ship) but was then made only of Beams joined together; in which they are reported to have paſſed the *Mediterranean Sea*; from the *Egyptians* it came to the *Græcians*, and one *Danatus*, of that Country, made a Ship of more ample Form than formerly, for which he was celebrated by the *Græcians* as the firſt Inventor. The Ship *Argos*, built only to ſail through the *Euxin* Sea to *Colchos*, was the firſt of *Note* among the *Greeks*, and, therefore, was by the ancients placed in Heaven among the Conſtellations in Memory thereof. But *Strabo* gives the Invention of it to *Minos*, King of *Crete*, who is reputed the firſt who built a Navy of Ships for War, and ruled over the Seas.

Others (as *Diodorus Siculus*) to *Neptune*, for which he was, afterwards, tranſlated into the Number of the Gods. Others, again, aſcribe the Building of Ships to *Dedalus*, a rare Workman in *Mechanical Occupations*. From the *Græcians* it was, afterwards, communicated to the *Italians*, amongſt whom the *Genoeſe* and *Venetians*, moſt excelled in this Matter, for we read of their great Riches and magnificent Power, eſpecially by Sea; after theſe aroſe the *Portugueſe*, who, under the Conduct and Direction of *Columbus*, an *Italian*, firſt diſcovered *America*, which gave an *Example* to other Nations to adventure farther; amongſt which no Nation hath waded farther than the *Engliſh*, who under *Drake* and *Candiſh* in the Time of Queen *Elizabeth*, ſurrounded the World, as ſays Capt. *Sturmy*.

When *Drake* and *Candiſh* ſail'd the World about;
And many *Hero*'s found new Countries out,
To *Britain*'s Glory, and their laſting Fame;
Were we like minded, we might do the ſame.

A brief Account of their Voyages round the Globe, you may ſee in *Morden's Treatiſe of the Globes*, p. 75.

Firſt Voyages *and* Diſcoveries *made in* America.

Firſt *Navigations* to *America*.

ANNO 1485. *Hernando Cortes* ſailed out of *Spain* to the Iſland of St. *Domingo*; and, afterwards, went to *Mexico*, where *Montezeuma* was Emperor, and (join'd with the *Taxalans*) conquered the *Mexicans*.

Anno 1492. *Auguſt* 3. *Chriſtopher Columbus*, with 120 Perſons, ſet ſail for to make Diſcoveries in *America*.

Anno 1496. Sir *Sebaſtian Cabot*, at the Charge of *Henry* VII. of *England*, ſailed to *America*, diſcovering from *Cape Florida*, all the *North-Eaſt* Coaſt thereof, beyond *Newfoundland* in the *North*.

Anno

Anno 1501. *Americus Veſpuſius*, a *Florentine*, employ'd by *Emanuel*, King of *Portugal*, to find out a nearer Way to the *Molucco's*, made a Voyage to *Cape Auguſtine*, on the *Coaſt* of *Braſil*, giving Name to all that vaſt Tract of Land, *viz. America*.

Anno 1520. *Ferdinando Magellanus*, a *Spaniard*, made his Voyage, and was killed.

Anno 1526. *Francis Pizzaro*, ſailed from *Spain* to the *Weſt-Indies*, to diſcover the *South-Sea*.

Anno 1530. Mr. *Hore* ſet out for farther Diſcovery of *Newfoundland*.

Anno 1567. Sir *John Hawkins* made a Voyage to to *Guinea*, with whom was Sir *Francis Drake*.

Anno 1572. Sir *Francis Drake* ſet ſail for *America*; in 1577 he made his Voyage round the World; in 1585 he made another Voyage to *America*; and in 1595 his laſt, where he died in his Voyage.

Anno 1575. Capt. *John Oxenham* ſailed for the *Weſt-Indies*, in a Ship of 140 Tuns, and loſt his Life.

Anno 1576, Sir *Martin Forbiſher* made his firſt Voyage; in 1577 another Voyage; and 1578 he made another Voyage, having 15 Sail of Ships.

Anno 1585. Mr. *John Davis* made his firſt Voyage for the *North-Weſt* Diſcovery; in 1586 a ſecond Voyage; and 1587 a third, making a Diſcovery to 73 Degrees of *North* Latitude.

Anno 1586; Sir *Thomas Cavendiſh* made a proſperous Circumnavigation of the Ocean, with 3 Ships and 120 Men.

Anno 1586, 89, 92, 94, and 97, The Right Honourable *George*, Lord *Clifford*, Earl of *Cumberland*, made ſeveral Voyages and Adventures againſt the *Spaniards* in *America*, the laſt, *viz.* in 1697, being with 18 good Ships, and 1000 Men under his Command.

Anno 1595. Sir *Walter Rawleigh* ſet ſail for *Guinea*, and, at his Return, enduring 14 Years Impriſonment, made, afterwards, another Voyage to *Guinea*, for Diſ-

covery of a Gold-Mine, but after his Coming back he was beheaded.

Anno 1602. Capt. *George Weymouth* ſet forth with two Fly-boats, at the Charge of the *Muſcovy* Company to find out the *North-Weſt* Paſſage.

Anno 1605. Capt. *James Hall* made his *Navigation* to *Greenland*; and in 1612. a fourth; being then ſlain by a Savage.

Anno 1605. *Stephen Burrough*, Mr. *Pet*, and Mr. *Jackman*, made a Navigation to *Nova Zembla*.

Anno 1607. Capt. *Henry Hudſon* made his Voyage to 80 Degrees of Latitude, and periſh'd in his Return, by ſome of his Men forcing him, his Son, and ſix more to go into a Shallop in the Night, and ſeek their Fortune.

Ships were never uſed in *England* 'till after *Ceſar*'s Coming, ſince which we have arriv'd to great Perfection in Building thoſe floating Caſtles, (the true Walls and Bulwarks of an Iſland) and have exceeded all Nations in their *Statelineſs*, *Structure*, and *Strength*; before that Time we had only ſome ſmall Veſſels made of Boards and Wicker.

For Voyages made to ſeveral Parts of the World, ſee thoſe publiſh'd by *Hennepin*, *Frykes*, *Miſſon*, *Dellon*, *Troger*, *Hack*, *Du Queſnes*, *La Salle*, *Wheeler*, *Patin*, *Rhamnuſius*, *Bernier*, *Sharp*, *Laſſel*, *Grelot*'s to *Conſtantinople*, Voyage to *Kilda*, to *Athens*, to *South America*, to Mount *Libanus*, *Brun*'s to the *Levant*, *Gage*'s to *New Spain*, the *Preacher*'s, *Coriat*'s *Crudities*, *Litthgow*'s, *Blank*'s, *Ray*, *Burnet*'s, *Vanſhal*, *Baritti*, *Glanius*, *Magellan*'s, *Dampier*'s, *&c.*

And, indeed, the *Art* of *Navigation* is wonderfully improved ſince the Coming of *Chriſt*, before which Time (if there be any Truth in Hiſtory) the Uſe of the Loadſtone was never known in the World, and before the Virtue of that was reveal'd unto the Mariner, it is unſpeakable with what uncertain Wandrings Sea-men floated here and there, rather than ſailed the right and direct

direct Way; and it was impoſſible to have ſail'd round the Globe, or made any new Diſcoveries or Improvements in Navigation, if it had not been found out to have a peculiar Direction to a Meridional (or N° and S°) Poſition. This was a Secret the firſt Finders out of the Loadſtone never imagin'd. And even this uſeful *Arcanum* had remain'd, perhaps, for ever undiſcover'd, if (like the Invention of Gun-powder) ſome particular Accident had not led us to the Conſideration of it; as you may ſee more at large in *Kercher de Magnete*. Nor would this ſecret Property of the Stone have been of Uſe, farther than in private Speculations, if Navigation had been unknown. Therefore, I hope, it may not be improper if we ſhew the Reader ſome of the *Properties* of the *Loadſtone*.

The *Magnet*, or *Loadſtone*, (though ſeemingly mean and contemptible) yet, for its wonderful *ſecret Properties*, and for its real Uſefulneſs to Mankind, and the great Improvements that have been made in *Navigation* by the Help thereof, may juſtly be admired amongſt the choiceſt Miracles of Nature, and valued above all the Gems and precious Stones in the Univerſe.

Theſe Stones, as they are found in divers Parts of the World, and are of different Colour, Weight, and Force, ſo they have different Degrees of *attractive* and *directive Power* and *Virtue*, but differ not in Property, for all have the ſame Direction; but ſome more weak, and ſome more vigorous and ſtrong, amongſt the reſt, thoſe that are found about *China* and *Bengal*, in the *Eaſt-Indies*, are reckon'd the beſt. But there are others alſo found in *Arabia*, ſome at *Porto Feraro* in the *Levant*; ſome there are alſo found in *High Germany*, *Norway*, *Spain*, and *Bohemia*; and ſome in the *Weſt* of *England*, and moſt commonly in Iron-mines, being ſuppoſed by ſome to be of the Iron Ore, or to participate of the very Nature of Iron itſelf, as appears by its ſympathetick Affection to Iron or Steel, in drawing it to

itſelf, as ſoon as it comes within the Orb of its Attraction; for if you apply a Piece of Iron to either Pole, it will there hold it, and, at a Diſtance, draw a ſmall Piece of Iron with more or leſs Vigour, according to the Strength of the Stone, which may be artificially augmented, by capping each Pole of the Stone with a ſmooth and bright Piece of Iron or Steel, into which, as into a Center, the Virtue of each Pole (which before was more diffuſed) will be contracted and united, and thereby the ſame Stone rendered more vigorous and powerful.

Of the ſympathetical *and* antipathetical *Properties of the* Loadſtone.

WHEN a Needle is touched upon a Loadſtone, the *North* and *South* Ends of this Needle will apply themſelves reſpectively to thoſe Poles from whence they received their magnetical Life, *i. e.* the *North* End of the Needle to the *North* End of the Stone, which denotes their mutual Sympathy; but putting the *North* End of the Stone to the *South* End of the Needle when it is upon a Pin, the *South* End of the Needle will immediately fly away; and if you put the *South* End of the Stone to the *North* End of the Needle, it will alſo diſcover its *antipathetical Nature*, and fly away from it.

But a contrary Operation there is yet in the two Needles, to that of the Loadſtone; for if one of the Needles be hung upon a Pin, that you apply the *North* End of the Needle to the *North* End of that upon the Pin, it ſhall immediately fly away; which denoteth a contrary Operation in the Needle to that of the Stone, and the *South* End of one will immediately come to the *North* End of the other.

The ſame Property of *ſympathetical Coition*, and *antipathetical Repulſion*, is alſo diſcover'd by two Loadſtones, floating in two little Boats, in a great Baſon of Water,

ter,

ter, the two Poles of either Stone being disposed parallel to the Horizon, and if you put both the *South* Poles together, they shall avoid the Contract of one another by a natural Antipathy; but if the *North* Pole of the one be directed to the *South* Pole of the other, they will immediately manifest their natural Sympathy one to another, and will cleave together by a strong Attraction.

If a Loadstone be confusedly broken into many Pieces, each of the Pieces shall be an intire Loadstone, having both its Poles distinctly of itself, with all the other Properties that were in the Stone before it was broken.

But if a Loadstone be divided in the midst, between the two Poles, in the Equinox, then it is absolutely two intire Loadstones; and those Parts which were the Equinoctials before, are now become two Poles, and the two Poles that were Poles before, do continue the same.

But if a Stone be cut meridionally quite thro' the two Poles, so that one Axis is now converted into two; it is also become two intire Loadstones; the Axis of either of them will retire into the Gravity of either Piece, and if you join these two Pieces together again, the two Axes will become one, which is most admirable to behold.

But if you cut off a Piece of the Stone at the very Pole, in a parallel Section, the Virtue of that Piec will immediately retire from it unto the main Ston and will scarcely have any Virtue at all therein; but applying this small Piece that was cut off, to the same Place again, the Stone will forthwith impart the same Virtue as before, into this Piece so cut off, so long as it doth abide in that Place.

Or, if you apply a weak Stone to the Poles of a strong one, the strong one will impart of its Virtue to the weak Stone, making it to be as strong as itself, but when this weak Magnet deserts this neighbouring Propinquity, the strong Magnet will draw its Virtue to

it

itſelf again, and will truſt it no farther than the Power of its Recal. Many ſurprizing Fancies may be performed by the Loadſtone, which I omit, as being not pertinent in this Place.

To find the Poles *of a* Loadſtone.

THERE are ſeveral Ways for the Performance of this Experiment. *Firſt*, You may have a thin Piece of Steel, about an Inch in Length, and half an Inch broad, which being bent circular, and laid on the Stone, will immediately lie parallel to the Axis of the Stone, and direct which Way the Poles do lie; which being diſcovered near where they lie, you may find them more exactly by a ſmall Piece of a ſewing Needle; which being laid on the Stone, if it be near either of the Poles, will elevate one End thereof, then move it farther and farther, 'till it doth erect itſelf perpendicular, and that very Point will be the Pole of the Stone.

Now to know which Pole it is, you may apply a ſmall Needle of a Dial to it, and if the Pole draw the *North* End of the Needle, then it is the *North* Pole of the Stone; and contrary.

Or, otherwiſe you may find the Pole by a ſewing Needle and Thread, by hanging it over the Stone where you ſuppoſe the Pole to be, and keep it a little ſhort from the Stone, and the End of the Needle will directly point to the Pole of the Stone. And this Diſcourſe of the Loadſtone leads me naturally to ſay ſomething of the *original Diſcovery* and *Invention* of the *Mariner's Compaſs*, and the *Excellency* thereof.

The original Invention of this moſt uſeful Inſtrument, (by the Help whereof the glorious Goſpel hath been tranſmitted into the moſt dark Corners of the Earth) ſome attribute to one *John Goia*, (or *Flavia Goia*, as others ſtile him) of *Amalphi* in *Campania*, in the Kingdom of *Naples*, who only accommodated the Superficies

perficies thereof with 8 Points, that is, four Cardinal, and four Collateral; and ſo left the Improvement of this Invention to be attempted by Poſterity.

Others do intitle the Invention thereof to the People of *China*. Dr. *Gilbert*, in his Book *de Magnete*, aſſerts, that *Paulus Venetus* tranſported it firſt into *Italy*, in the Year 1260, having learnt it from the *Chineſe*.

And *Ludi Vertomannus* affirms, that when he was in the *Eaſt-Indies*, about the Year 1500, he ſaw a Pilot of a Ship direct his Courſe by a Compaſs faſhioned and framed as thoſe which now are commonly uſed.

And Mr. *Barlow*, in his Book intitled, the *Navigator's Supply*, *Anno* 1597, relateth a Story of two *Eaſt-Indians* that he had perſonal Conference with, (one of them was of *Mamilia*, in the Iſle of *Luzon*, the other of *Miaco*, of *Japan*) who declared, that inſtead of our Compaſs, they uſe a magnetical Needle of ſix Inches, and longer, upon a Pin, in a Diſh of white *China* Earth filled with Water, in the Bottom whereof they have two croſs Lines for the principal Winds, the reſt of the Diviſions being left to the Skill of their Pilots. Alſo he there relates, that the *Portugueſe*, in their firſt Diſcoveries of the *Eaſt-Indies*, got a Pilot of *Malinde*, that brought them thence in 33 Days within the Sight of *Calecut*; by which it appears that then they had the Uſe of the Compaſs.

But let the Invention be attributed to whom it will, 'tis manifeſtly known to have received its abſolute Perfection in theſe Parts of the World: But, more particularly, the Compleating of this Invention is due to the People of *Antwerp* and *Bruges*, and alſo to our own Nation, by annexing to the Compaſs 24 ſubordinate Winds or Points; and alſo on the Limb thereof 360 Degrees, which are numbered from *North* to *South* towards the *Eaſt* and *Weſt*, with 10, 20, 30, *&c.* So that each Point containeth 11 ¼, and upon the *North* Point there is a Flower-de-luce, to diſtinguiſh it from the

the reſt of the Points, as you may ſee in the enſuing Treatiſe.

Before the Invention of this rare Inſtrument, Seamen were directed in their Voyages by certain Stars they took Notice of, eſpecially the *Pleiades*, or ſeven Stars, by *Charles*'s Wain, and the Pole-Star and Guards in the *Little Bear*, which were therefore called Load-Stars. Alſo Travellers in the Deſarts of *Arabia*, and thoſe of *Tartary*, were guided by ſome fixed Stars in the Night-time, to ſteer their Courſes in thoſe pathleſs Ways. So Seamen were directed by the like heavenly Guides in the unbeaten Paths of the Ocean, before this excellent Artifice was diſcovered. But if the Sky happened to be overcaſt, then the moſt experienced Mariner was at a Loſs, and was conſtrain'd to come to an Anchor, or to lie by, to wait the Appearance of his cœleſtial Directors. Alſo *Pliny* tells us of the Inhabitants of *Sumatra*, who, becauſe they could not behold the Pole-Star to ſail by, carried certain Birds to Sea, which they often did let fly; and as thoſe Birds, by natural Inſtinct, applied their Flight always to Land, ſo the Mariners directed their Courſe after them.

To theſe, and the like Difficulties, were Men expoſed, before the Invention of this marvellous Inſtrument; and by it Poſterity is furniſhed with a noble Remedy againſt this grand Inconvenience; and a Method diſcovered, as by an immediate Meſſenger from Heaven, to ſteer an infallible Courſe in the moſt gloomy Nights and tumultuous Seas, and by the Providence of the Almighty be ſafely conducted to the deſired Port.

Yet the Mariner's Compaſs is not abſolutely perfect (by that acquired Virtue it receives from the Loadſtone) but that it requires ſome Improvements, becauſe it doth not conform itſelf to the true Meridian in all Places; bnt varies in ſome Places more, in ſome leſs, from the direct Poſition of the true *North* and *South*. This Variation of the Compaſs augments the Mariner's Care, and ought to be, conſequently, conſtantly obſerved in

all

all Voyages, the Neglect of which may expose them to many Dangers: The Manner how to observe it, and find its Quality and Quantity shall be shewed in its proper Place. And the Sea-compass is nothing else than a Box, having a brass Pin in the middle, upon which a round Piece of Paste-board with the 32 Points printed on it, (furnished with a hollow Center, called the Cap, and a Piece of Steel or Iron Wire) always moves. This Wire being commonly bent in Form of a *Rhombus*, one of its Angles lying under the *North* Point, or *Flower-de-luce*, the other opposite Angle lying under the *South* Point thereof. This Instrument being thus far prepared, they take the Card, or stiff Paper, the Wire being first fastened to it, and rub the acute Angle of the *Rhombus*, which lies under the *North* Point, upon the *South* Pole of the Loadstone, and the opposite acute Angle of the *Rhombus*, which lies under the *South* Point of the Card, they rub upon the *North* Pole of the said *Magnet*, or Stone, and then the Card being placed in an *Equilibrum*, with its Cap upon the Pin, does (by an unaccountable Property of the Stone) apply itself to the true Meridian, either *North* and *South*, or near to that Position. And this is the Construction of the Mariner's Compass.

I shall conclude this Head about the Loadstone and Compass, in the Words of the Noble Lord *Dubartus*.

Slate, *Jet*, and *Marble*, shall escape my Pen;
I over-pass the Salt-mount *Oromene*;
I blanch the Brine-quar-hill in *Arragon*,
Whence there they powder their Provision.
I'll only now emboss my Book with Brass,
Dye't with Vermilion, deck't with Copperas,
With Gold and Silver, Lead and Mercury,
Tin, Iron, Orpine, Stibium, Lethargy:
And on my Gold-work I will only place
The Chrystal pure, which reflects each Face;
The precious *Ruby*, of a sanguine hue,
The Seal-fit *Onyx*, and the *Sapphire* blue,

The

The *Caſſidonie*, full of Circles round,
The tender *Topaz*, and rich *Diamond*,
The various *Opal*, and green *Emerald*,
The *Agath* by a thouſand Titles call'd,
And Sky-like *Turques*, purple *Amethiſts*,
And fiery *Carbuncle*, which Flames reſiſts;
For what are theſe to th' admired *Adamant*,
Whoſe dead-live Power my Reaſon's Power doth daunt.
Renowned *Loadſtone*, which on Iron acts,
And by the Touch the ſame aloft attracts;
Attracts it ſtrangely with unclaſping Crooks,
With unknown Cords, with unconceived Hooks,
With unſeen Hands, with undiſcerned Arms,
With hidden Force, with ſacred ſecret Charms,
Wherewith he wooes his *Iron Miſteriſs*,
And never leaves her 'till he gets a Kiſs;
Nay, 'till he folds her in his faithful Boſom,
Never to part, except we (love-leſs) looſe 'em;
With ſo firm Zeal, and faſt Affection
The Stone doth love the Steel, the Steel the Stone.
And tho', ſometime, ſome Make-bate come betwixt,
Still burns their firſt Flame, 'tis ſo ſurely fixt;
And while they cannot meet, to break their Minds,
With mutual Skips they ſhew their Love by Signs:
As baſhful Lovers, ſeeing Strangers by,
Parley, in Silence, with their Hand or Eye.
Who can conceive, or cenſure, in what Sort
One Loadſtone touched *Ann'let* doth tranſport
Another Ring, and that another,
'Till four or five hang dangling one in other?
Greateſt *Apollo*, might he be (methinks)
Could tell the Reaſon of theſe hanging Links.
Since *Reaſon-Scanners* have reſolved all,
That heavy Things, hang'd in the Air, muſt fall.
But who hath ſhewn, with arguing Subtilty,
The ſecret Cauſe of this rare Sympathy.
But ſay, *Lucretius*, what's the hidden Cauſe,
That toward the *North-Star* ſtill the *Needle* draws,

Whoſe

Whoſe Point is touch'd with Loadſtone? Loſe this Knot,
And ſtill green *Laurel* ſhall be ſtill thy Lot:
Yea, Thee more learned, will I then confeſs,
Than *Epicurus*, or *Empedocles*.
W'are not to *Ceres* ſo much bound for Bread,
Neither to *Bacchus* for his Cluſters red,
As Signior *Flavio*, to thy witty Trial,
For firſt Inventing of the Seaman's Dial,
(Th' Uſe of th' Needle turning in the ſame)
Divine Device! O admirable Frame!
Whereby, thro' th' Ocean in the darkeſt Night,
Our hugeſt gallant Ships are conducted right;
Whereby we're alſo ſtored with Guide and Lamp
To ſearch all Corners of the watry Camp,
Whereby a Ship, that ſtormy Heav'ns have whirld,
Near, in one Night, into another World,
Knows where ſhe is, and in the *Card* deſcries
On what Point o'th' Compaſs her Port deſired lies.

And thus we read *Dedalus*, with his Son *Icarus*, were the firſt who applied Maſts and Sails to Ships, for 'till then they only uſed Oars. Others invented Rudders, Anchors, *&c.* by which Shipping has been gradually brought to the Perfection in which we find it at preſent.

Of the Excellency and Uſefulneſs of Navigation.

CAPTAIN *Sturmy*, in the Beginning of his *Magazine*, ſays, "*Navigation*, of all other Arts and "Sciences, (ſetting Divinity aſide) hath much Reaſon "to have the Preheminence; it being of ſuch neceſſa- "ry and publick Concernment, and what Uſe there is "made of it by Seamen, at this preſent, as well as "hath been in Times paſt; all Men know to whom "theſe Countries are beholden for their good Service, "whoſe Courage hath kept *Great-Britain*, Queen and "Regent of the Sea; which deſerves it well, in Re-

"ſpect

" ſpect of the Skill and Valour of her Mariners, and " Goodneſs and Number of her Ships. I wiſh as " long as the Sun and Moon endure, that they may " maintain their Courage, and improve their Art, as " they ever have againſt all Nations that have been " *England*'s Enemies, and ever may they crown their " Undertakings with everlaſting *Credit*.

" The *Art* of *Navigation* being ſuch, I think I " may boldly affirm, without Preſumption, this Art " is more neceſſary for the Well-being and Honour " of our Nation, than any other Art or Science Mathema- " tical, which is more carefully kept in the Univer- " ſities. Look upon *Grammar*, *Rhetorick*, and *Logick*, " theſe are but Introductions to other Arts, and *Mu-* " *ſick*, indeed, is only commendable in the Service of " God; and for private Perſons innocent Solace and " Delight.

" The chief Profeſſions now in the Univerſities are " *Phyſick* and *Law*, without Envy be it ſpoken, we may " as well live as the ancient *Romans*, without *Phyſicians*, " and as honeſt Neighbours, without *Lawyers*, better than " without skilful Seamen, which are the chief Importers " of our Wealth, and Supporters of our Welfare.

" Beſides that, of all mathematical Sciences and Arts " profeſſed in the Univerſities, of this Art of *Naviga-* " *tion* is made the moſt general and profitable Uſe: For " what can the Scholar make of his *Geometry*, with all " the nice and notional Problems thereof; or of *Aſtro-* " *nomy*, with all his curious Speculations about the Mo- " tion of the Sun, Stars, and Planets, without they be " applied to ſome more mechanical and practical Arts, as " *Coſmography*, *Geography*, *&c.* wherein it will appear that " the *Art* of *Navigation* comprehends them all in the Uſe " thereof. So that no *Art* is more capacious, and were " the Excellency well underſtood, and put in Practice as " it might be (as Mr. *Philips* ſaith in the like Caſe) no " Employment would be more honourable and advan- " tageous for the moſt generous Gentleman and learned

" Student,

" Student, than this of Navigation; and in ano-
" ther Place the ſaid Author ſaith, I do not
" think that there is any Man, that either re-
" gardeth God's Glory, or eſteemeth of human
" Society, but holdeth this Art worthy to be
" number'd with the moſt excellent that are exer-
" ciſed among Men: And therefore it is great Rea-
" ſon the Practicers of it ſhould be had in greater
" Reputation than they be now-a-days. Neither
" is there any other Art wherein God ſheweth his
" divine Power ſo manifeſtly as in this; permitting
" unto us certain Rules to work by, and increa-
" ſing of them from time to time, growing ſtill on
" towards Perfection, as the World doth towards
" its End; and yet reſerveth ſtill unto himſelf the
" managing of the whole, that when we have done
" what we can, according to Skill we have already,
" or may have by any thing we may learn here-
" after: Yet always will God make it manifeſt,
" that he alone is Lord and Ruler of Sea and
" Land, that *all Storms and Tempeſts do but fulfil*
" *his Will and Pleaſure*, who oftentimes admini-
" ſtreth many Helps beyond Expectation, *when the*
" *Art of Man utterly faileth*; which is lively ex-
" preſſed in *Pſal.* 107. where is nothing omitted
" which is neceſſary, nor any thing affirmed but
" that which the continual Experience of Seamens
" daily Dangers do proclaim to be true.

And ſo Mr. *Sellers*, in his *Practical Navigation*, gives this Encomium of the Mariners Art; ſays he, " Navigation (that uſeful Part of the Mathe-
" maticks) is a Science which has been highly
" valued by the Ancients, eſpecially by our An-
" ceſtors of this Iſland; it being indeed the Beauty
" and Bulwark of *England*, the Wall and Wealth
" of *Great-Britain*, and the Bridge that joins it
" to the Univerſe.

" The principal Handmaids that expert Mariners " are furniſhed with, that their Undertakings may " be crowned with everlaſting Credit, are theſe, *viz.* " *Arithmetick*, *Geometry*, *Trigonometry* and *Aſtronomy*. " By the Operation of theſe loving Sifters, (three " of the Liberal Sciences and excellent Arts,) *Navi-* " *gation* is daily practiced by the expert Mariner: " But much abuſed by many ignorant Aſſes, that " know little or nothing what belongs to them, " yet do undertake Voyages, reſting wholly upon " favourable Fortune, which hath made ſome of " them famous; but many times diſaſterous Pe- " riods have ended their Undertakings, with the " Loſs of many Mens Goods and Lives, and con- " ſequently the impoveriſhing of many Families.

Navigation is therefore a Science or Art, to be conſider'd two Ways, to wit in its *Theory* and in *Practice*, that being properly an Art which puts into Practice thoſe Precepts and Problems invented or taught by *Theory*, which is a Science; and theſe two are inſeparable Companions, which always wait upon Perfection, and of theſe (*Deo adjuvante*, God willing) I ſhall demonſtrate according to my Ability, and that in all the modern Methods or Improvements, in ſuch a regular Order, as I judge they ſhould be taught or learned:

Yours,

I. K.

The

The Compleat

Modern Navigator's TUTOR:

OR

NAVIGATION

IN ITS

Theory and Practice, Curiosity and Utility.

PART. I.

CHAP. I.

Domestick or Coasting NAVIGATION.

OF the common Notes of the *Julian* Kalendar, and such other Notes, of the Moon's Motion, as are necessary to be known by the young *Navigator.*

Luna, the Goddess of the silent Night,
Phœbe, *Diana*, various Flux of Light,
Prime Ruler of moist Bodies, and of what's contain'd
In Water-works, whether by Sea, or Land.
She's the lowest Planet, who in seven
And twenty Days goes round the Heaven;

And about two Days more that she must run,
Before that she doth overtake the Sun:
So twenty-nine and half she rounds her Silver Ball,
To make one Month we call Synodical.
Cynthia, thou second Honour of the Lamps supernal,
And sure Calendar of Festivals eternal;
Sea's *Sov'raintess*, Sleep-bringer, Pilgrims Guide,
Nocturnal Queen: What shall I say beside?
By thine Influence the Sea doth ebb and flow,
As thou th'horn'd Queen doth either shrink or grow.
Yet of thy self thou hast no innate Light,
But what thou get'st from *Titan's* Beams most bright.

§. 1. *Of the Sun's Cycle*

This Circle maketh its periodical Revolution in 28 Years, and was invented principally, thereby to know the true Order of the Dominical or Sunday Letter for any Year.

To find this Number for any Year.

Rule. Add 9 to the Year given, (for when Christ was born this Number was 9) and divide that Sum by 28, the Quote tells how many Revolutions this Circle hath made since the Birth of our Saviour, and the Remainder is the Circle of the Sun for the Year required.

Exam. What's the Sun's Circle for the Year 1724?

1724+9=1733, which divided by 28 Quotes 61 Circles, and the Remainder 25 is the Circle of the Sun for *Anno* 1724.

2. *Of the Prime or Golden Number.*

This Circle makes its Revolution in 19 Years; in which Time all the Lunations and Aspects between the Sun and Moon do nearly return to the same Place they were at 19 Years before.

To find this Number for any Year.

Rule. Add 1 to the Year, (for when Christ was born this Number was 1) and divide the Sum by 19; the Quotient shews you how many Circles of the Prime is made, and the Remainder is the Prime for that Year.

Example. What's the Prime for the Year 1724?

1724 + 1 = 1725, and this divided by 19 Quotes 90, and the Remainder 15 is the Prime required.

3. *Of the Epact.*

The *Epact* is a Number never exceeding 30 (or the Moon's Age) and is the Difference between the Sun's Year of 365 Days, and the Moon's Year of 354 Days, *viz.* 11 Days, from whence, as an additional Supply, the Epact takes its Name.

To find this Number for any Year.

Rule. Multiply the Prime (before found) by 11, and divide the Product by 30, the Remainder after Division is the Epact.

Example. What's the Epact for the Year 1724, Prime being 15?

15×11=165, which ÷ by 30, the Remainder after Division is 15, the Epact required.

4. *To find the Moon's Age at any Time.*

Rule. To the Epact (before found) add the Day of the Month, and the Number of Months from *March* (which are these; *Jan.* 0. *Feb.* 2. *Mar.* 1. *Apr.* 2. *May* 3. *June* 4. *July* 5. *Aug.* 6. *Sept.* 8. *Octob.* 8. *Novemb.* 10. *Dec.* 10.) the Sum is the Moon's Age; but if the Sum exceed 30, ſubtract 30 therefrom; the Remainder is the Days of the Moon's Age.

Exam. What's the Moon's Age *May* the 5th, 1724?

Epact (before found) is 15 + Mo.-Day 5 + N°. 3 = 23 Days, the Moon's Age required.

5. *To find the time of the Moon's Culmination, coming to the Meridian; or the time when ſhe comes to the South, Vulgarly called the Moon's Southing; which (with the Tides) differs each Day, in Time,* 48 *Minutes, or* $\frac{4}{5}$ *of an Hour.*

Rule. Multiply the Moon's Age (before found) by 4, and divide that Product by 5; the Quotient is Hours, and the Remainder ſo many 12 Minutes of an Hour, and both together is her Southing.

Example. The Moon being 23 Days old, I demand at what time ſhe comes upon the South Part of the Meridian?

Note, If the Moon's Age exceed 15 Days, reject 15, and work with the Remainder; for the Moon has the ſame Southing after the Full, as after the Change; that is, her Southing is the ſame at 16 Days Age as at 1, at 17 as 2, *&c.*

Therefore $23-15=8$ & $8\times 4=\frac{32}{\div 5}=6$, & 2 remains

remains, which is (2×12) = 24 Minutes, so that the Moon's Southing is 6 Hours 24 Minutes, which was required.

6. *To find the time of full Sea at any Place, Vulgarly call'd, To shift the Tides.*

Rule. To the Moon's Southing (for the time given) add the Hours answering to the Point of the Compass, making full Sea (on the Full or Change of the Moon) at the Place propos'd; the Sum is the time of full Sea, or High-Water (after Noon) at the said Place.

Example. I demand the time of High-Water (on the 5th of *May*, 1724) at *Yarmouth*?

The Moon's Southing (before found) is $6^h\ 24^m$ and by our general Tide-Table, it flows at *Yarmouth* S. S. E. and N. N. W. on the Full and Change Days, which is $10^h.\ 30^m.$ in Time: Then $10^h.\ 30^m. + 6^h.\ 24^m. = 16^h.\ 54^m.$ from Noon, *Viz.* $4^h.\ 54^m.$ in the Morning, (rejecting 12 Hours.)

7. *To find how long time the Moon doth shine in the Evening after the Sun is set; or in the Morning before the Sun rises.*

Rule. Multiply the Moon's Age by 48, and divide that Product by 60, the Quote is the Hours, and the Remainder the Minutes of Time of her Shining: And this is when the Moon is less than 15 Days Old; — but if the Moon be more than 15 Days Old, subtract the time of her Shining (found as before) from 24 Hours, and the Remainder will be the time of her Shining in the Morning before the Sun rises.

Exam. How long will the Moon shine upon the 5th day of *May*, 1724?

The Moon's Age (found as before) is 23 ^{days} $\times 48 = 1104$ which $\div$ by 60 is $= 18^h\ 24^m - 24^h\ 00^m = 5^h\ 36^m$ the time of her Shining in the Morning before the Sun rises.

8. *To find how many Signs and Degrees of the Zodiack the Moon is departed from the Sun since her last* Conjunction *with him.*

Rule. Multiply the Moon's Age by 2 and divide that Product by 5; the Quote shall give the Number of Signs, and the Remainder, (if any be) every Unit thereof is 6 Degrees.

Exam. The Moon being 22 Days Old, how many Signs hath she departed from the Sun, since her last Conjunction, or New Moon?

$22 \times 2 = 44$ which $\div$ by 5, the Quote is 8 Signs and 4 remains, which is 24 Degrees: So that the Moon is departed from the Sun $8^s : 24°$.

9. *To find the Moon's Place in the Zodiack at any Time.*

Exam. In what Sign and Degree of the Ecliptick will the Moon be on the 20th of *January* 1723?

1. By our Table of the Moon's Changing, it was New Moon on the 3d Day, 11 Hours in the Morn. and the Sun that Day at Noon, was in $27° : 03'$ of (♑) *Capricorn*, and so was the Moon also. Then 20 Days less 3 Days 11 Hours is $= 16$ Days 13 Hours.

2. Then in the Table of the Moon's Motion, seek under Title ☽ *Mot.* for 16 Days 13 Hours, and set them under the Sun's and Moon's Place.

These three Numbers added together will give the Sign and Degree in which the Moon is.

The Operation for the Moon's Place *Jan.* 20th, 1723.

The

The Moon changed *Jan.* 3d, at which time the Sun was in 27° : 3′ of ♑ *Capricorn*, that is,	S	0	′
	9	27	3
The Moon's Motion in 16 Days is, —	7	00	49
The Moon's mean Motion for 13 hours is	0	07	08
The Sum	17	05	00
Reject a Circle or Signs	12	00	00
The Moon's Place	5	05	00

That is, in 5° 00′ of ♍ or *Virgo*, that being the fifth Sign from ♈.

Note, According to the Moon's Distance from the Sun, is the Variation of her Phases, or Appearances: For she being a round opaque globular Body, and having always that Hemisphere of her that beholdeth the Sun enlightned, she must of Necessity, as she moves round the Earth, changing her Situation, both in respect of the Sun and us, have a different Appearance, by turning more or less of her illuminated Hemisphere towards us.

Her Phases are usually accounted four, according to her four-fold Aspect, the Conjunction being esteem'd none, seeing her enlightned Half is then wholly turned from us.

About the third Day after the Conjunction, she emerges in the Evening out of the Sun's Rays, and turns a small part of her illuminated Side towards us, beginning to appear sharply horned, her Horns looking backwards and tending towards the East: For *note*, that while she increaseth in Light she followeth the Sun, and shineth after Sun-set, her enlightned Part looking into the West; but decreasing she goeth before the Sun, and shineth

before

before his Rising, her illumminated Part looking into the East. And when she comes to make about a Sextile Aspect with the Sun, that is about 2 Signs from the Sun, her first Face is called horned: She makes her second Phase about the 7th or 8th Day of her Age, being then about 90 Deg. or at a Square to the Sun, appearing half enlightned or bisected. Afterward coming to her Trine with the Sun, she appears Gibbous, tum'd or swell'd, which is her third Phase. Her fourth is, when in Opposition to the Sun, she appears wholly illuminated, and is called her Full. She makes the like Phases in her Decrease, but in a retrograde, (or backward) Order.

10. *Of a Year, and Kinds of Months.*

A common Year is 365 $\frac{1}{4}$ Days (but more exactly from Solar Observations, its found to be $365^{d}\ 5^{h}\ 49'\ 04''$.) And a Leap Year, (or Bissextile) 366 Days

A Month is either Solar, Lunar, or Civil. — The Solar Month is the Space of Time that the Sun is passing a Sign, that is, the $\frac{1}{12}$ of the Ecliptick, or 30 Degrees; which is about 30 Days: So that the Sun's Motion is about 1 Degree in a Day; (but more exactly, the Sun moves in one Day $59'.\ 8''.\ 19'''.\ 43''''.\ 47'''''.\ 21''''''.\ 29'''''''$.).

The Civil Month is a space of Time more or less according to the Pleasure of the Magistrate or Civil Power, and is in our *Julian* Kalendar according to this Rhime;

Thirty Days hath Fruit-bearing *September*,
Moist *April*, hot *June*, and cold *November*;
Short *February* Twenty-eight alone;
The other Months each claims his Thirty-one:
But when of Leap-year comes the Time,
Then *February* hath Twenty and Nine:

For

For *February*, when her fourth Year's run,
Does gain a Day from the Traveling Sun.

The Lunar Month is either Periodical, or Synodical.

The Periodical Month is 27 Days, 7 Hours, 43 Minutes; being the space of Time in which the Moon passing from one Point of the Zodiack thro' the 12 Signs, returns to the same again.—The Synodical Month is about 29 ½ Days, the Space of time between one Conjunction of the Sun and Moon and another.

Having not room here to treat at large of the *Julian* and *Gregorian* Kalendars, (I refer the Reader to my *Ecclesiastical Astronomy* in the *English* Academy, where he may receive ample Satisfaction;) I shall only here briefly speak of them, and offer an Essay towards the Emendation of the *Julian*, which we account by.

The *Julian* Account derives its Name from the Emperor *Julius Cæsar*, who about 38 Years before *Christ*, being instructed by expert Mathematicians from *Alexandria*, found the Year wanted 10 Days 6 Hours *fere* of the Solar or Tropical Year, (it being then accounted but of 355 Days from *Numa Pompilius*) and by the Assistance of *Sosigene* an able Astronomer, he (after the Conquest of *Pompey*) regulated the Year; adding the 10 Days wanting to it, and made it consist of 365 Days, which were divided into 12 Months, in the same manner as they are at this Day: And, lest the odd 6 Hours should create a Disorder in the Year afterwards, he order'd that every 4th Year, 1 Day should be intercalated or put into the Month of *February*, between the 24th and 25th Days of that Month; which according to the *Roman* or old *Latin* Calendar, was called *Sext. Calend. Martii*, or the 6th of the Ca-

lends

lends of *March*; and by the Interposition or Intercalation of this Day there was two *Sext. Calend. Martii*; and the Word *bis*, Latin for two, being added to *Sext.* or *Sextilis*, it signified twice the Sextile, and made *Bissextilis*, or *Bissextile*, which is the Meaning and Formation of the Name; but we call it in *English* Leap Year, probably from the *Dutch*, *Loop-iare*, because it leaps beyond or exceeds the Bounds of other Years by a Day.

And this is the State of our *Julian* Account, that has remained in Use ever since some time before the Birth of our Saviour.—— Now the *Gregorian*, or New Stile, is that by which our Neighbours in most parts of *Europe* reckon by. But our *Julian* Year, as aforesaid, being made of 365 Days, 6 Hours, is greater than the true Solar Year, *viz.* of 365 Days, 5^{h} 49.′ 04.″ 21.‴ by 10.′ 55.″ 39.‴ which altho' but a little Time, yet in many Years makes a great Variation, amounting to a whole Day in 132 Years *plus minus*: for in 10.′ 55.″ 39.‴ are 39339,‴ and in 1 Day or 24 Hours are 5184000‴; then divide 5184000 by 39339‴ the Quotient is 132 Years, the Space of Time in which we must necessarily lose one Day, by our *Julian* Account. Now, if you divide 1723 by 132, the Quotient is thirteen Days that we have lost in the *Julian* Account, since the Birth of our Saviour; thereby causing an apparent Anticipation of the Equinoxes, and Solstitial Points, insomuch that the Vernal Equinox, whose Place at the first Council of *Nice*, *Anno Dom.* 324, was the 21st of *March*, is now by Astronomical Observations fled back to the 9th enter 10th of *March*; so that there has happened to be two *Easters* in one Year, or within the Compass of 365 Days, as it may still happen, reckoning by the Old or *Julian* Calendar: By which sometimes there is five Weeks Difference between the

Canon

Canon or Rule for it in the *Common-Prayer-Book* and the *Almanack*; as it was in the Year 1663, and it has differed a Week more than 20 times since the Year 1600. and in the Years 2437, 2467, 2491, (if the World last so long) there will be an Error of 42 Days; and not long after that, of 49 Days; and if this *Julian* Account remain in Use till the Year 2698, it will never more happen according to the Rule of the Church; nay, further, this is so erroneous, by the Retrogradation of the Equinox, that in Process of Time (if no Correction be made) *Christmas* will fall in *June*, and *Midsummer* in *December*.

In Consideration of which in the Year 1582, *Gregory* the 13th being then Pope, by the Assistance of *Antonius Lilius*, his Brothers, and other eminent Mathematicians, set about regulating this Disorder, correcting the *Roman* Calendar, appointing the Year should contain 365 Days, 5 Hours, 49 Minutes, 12 Seconds: And that the Vernal Equinox, which was then on the 11th of *March*, should be brought up again to the 21st of *March*, as it was at the Time of the first Council of *Nice*, *Anno Domini* 324. And to effect this, he ordered that 10 Days should be left out of *October*, from the 5th to the 15th; so that the 5th Day of *October* was reckoned in the Calendar for the 15th Day of *October* that Year 1582. And because the Sun still gains as he did before, those that go by the *Gregorian* Account, do still every Century or 100 Years, (to reduce the Equinoxes 1 Day backward) reckon one Day sooner than before; so that now since the Year 1700, till the 1800, they are 11 Days before us, in the *Julian* Account; and therefore the first of *January* with us, is the 12th of *January* with them. And to retain the same Equinoctial Spring invariable upon the same Day, it was appointed

at

at the said Emendation, that of 400 Years the first, second, and third Hundred, the Leap (Year) Day (which in the *Julian* Year falls in Course) should be omitted and not intercalated, but on the 400dth Year, then the Leap-day should not be omitted, but reckon'd in: So that in 400 Years they thought fit to omit 3 Leap-Years, and for Memory sake, appointed the first Omission to be accounted from the Year 1600, not from 1582, in which the Reformation was made, because it was not only near the Time in which the Emendation was begun, but also the Equinox had not made an Anticipation of 10 Days from the Place thereof at the Time of the *Nicene* Council, which was *March* 21.

The Years then 1700, 1800, 1900, which should have been Leap Years, are to be accounted common Years, but the Year 2000, must be a Leap-Year: In like manner the Years 2100, 2200, 2300, shall be common Years, and the Year 2400, Bissextile, and so forward.

And although this *Gregorian* Account is not so perfect as it should be, being reduced no farther back than till the Council of *Nice*, about the Year 324 *post Christum*, and still wanted 2 Days of right; whereas it ought to have been reduced to the Time of Christ's Birth. Yet the Quantity of the *Gregorian* Year 365 Days, 5 Hours, 49 Minutes, 4 Seconds, 21 Thirds, agrees better with the heavenly Motion, and the Equinoxes and Solstices are more firmly fixed by it, and *Easter* celebrated more according to the Direction and Mind of the *Nicene* Council, than by the *Julian* Account of 365 Days, 6 Hours; and therefore does, and will bear away the Garland from it, and makes it be esteem'd a Stranger to Truth.

It is therefore to be wish'd, that a Reformation may be made in our old and erroneous Calendar,

(in

(in this our Nation, so flourishing in Arts and Sciences, not inferior to any in the World for Polity, Arms, and Learning) towards which I shall humbly offer what follows; *viz.*

The main Reason objected (as I take it) against an Emendation in this Nation, is, the Confusion that would follow about the Dates of our Civil Contracts, Bonds, Deeds, Payments of Rents, *&c.* To which I answer; that if we cannot be prevailed with to agree with the Pope's Method of cutting off 13 Days in some Month, yet that Publick Authority might direct that the odd Days, *viz.* one Day in the Months of *January*, *March*, *May*, *July*, *August*, *October*, *December*, each consisting of 31 Days, may be omitted for two Years, except in one of the Months; or at least that all Leap Years were omitted but 52 Years; that alone would gradually and insensibly, without the least Inconveniency bring us two Days before the *Gregorian*, and be agreeable to the Sun's Place at our Saviour's Nativity: Whereas the *Roman* Account, being reduced to the Council of *Nice*, would be two Days less exact. And if after that the Bissextiles be kept as before, except in every 132 Year, wherein a Leap-Day must be exempted for ever; or else that 1 Leap-Year be struck off every 100 Year, except in each 400 Year for ever; there would need no more to have our Festivals kept according to primitive Observation: For by supposing the Tropical Year to be as aforesaid (according to *Bullialdus*) $365^{d}. 5^{h}. 49'. 4''. 21'''.$ the annual Redundancy allowed, it will be $10'. 55''. 39'''.$ which compleateth 1 Day in 132 Years, and but $2'. 25''. 48'''.$ over; and 3 Days in 400 Years with $51'.$ over, which makes but one Day in 11294 Years, and therefore very inconsiderable. But to return from this Digression (if it may be so thought)

thought) I proceed now, to find when it's Bissextile or Leap-Year. *Rule.*

Divide the Year by 4, what's left shall be
For Leap-Year 0; for past 1, 2 or 3.

11. *What's the Year* 1723.

$\frac{1}{4}$ of 1723 is 430 Leap-Years since Christ's Nativity, and 3 remains which shews it's the Third after the Leap-Year.

12. *To find the Dominical or Sunday Letter.*

The Dominical Letter is always one of these seven, *viz.* A 1, B 2, C 3, D 4, E 5, F 6, G 7, and doth shew Sunday in the Kalendar and Almanacks all the Year; to find which this is the *Rule*,

Divide the Year its 4th, and 4 by 7.
What's left subtract from 7, the Letters given.

Example 1. What's the Dominical Letter for the Year 1723?

1723 + its $\frac{1}{4}$ = 430 + 4 = 2157 which ÷ by 7 the Remainder is 1. And 7 — 1 = 6 or F, the Dominical Letter required.

Example 2. What's the Sunday Letter for *Anno* 1724, being Leap-Year?

Note 1. When it is Leap-Year, there are two Dominical Letters; one serves to the 25th of *February*, the other from thence to the Years end.

2. The Dominical Letter goeth backward in a common Year one Letter, but in Leap-Year two Letters.

3. The Leap-Year having two Dominical-Letters, it is the latter of them that is found by the Rule above.

1724 + its $\frac{1}{4}$ = 431 + 4 = 2158 which ÷ by 7, the Remainder is 2. And 7 — 2 = 5 or E, to which

which annex the next Letter in order D, it is ED the Dominical-Letters required.

13. *To find the Dominicals, Sun's-Circle, Prime, Epact, moveable Feasts, Eclipses, Moon's Age, Moon's Southing, her Shining, Moon's Distance from the Sun, Moon's Motion, Moon's Rising and Setting, and Time of High-Water at any Place, by Inspection in our Tables.*

Example. January 12*th Anno* 1723. *Table* 1. The Dominical-Letter is F, Sun's Circle 24, the Prime 14. Epact 4. Shrove-Sunday, *Feb.* 24. Easter-Day, *April* 14. Whit-Sunday, *June* 2. And there is two Eclipses this Year of the Sun but both invisible to us.

D. Mo. D.

Table 3. Moon changed *Jan.* 25, and 30—12= 18 Days, the Moon's Age, *Jan.* 12. And the Moon's Southing is $2^h.\ 24^m.$

Table 5. Moon's Age being 12 Days, 'tis High Water at *London*, *Tinmouth*, *Hartlepole*, *Whitby*, *Dundee*, *Amsterdam*, *&c.* at $11^h.\ 48^m.$ it flowing Full and Change of the Moon in those Places N. E. b. N. and S. W. b. S.

Table 2. The Moon being 12 Days old as before; She shines $9^h.\ 36^m.$ in the Evening after Sun-set. She is distant from the Sun, 4 Sines 24 Degrees.—Her Motion is $5^s.\ :\ 8^\circ\ :\ 7'.$ and her Rising and Setting as by the Table adjacent.

14. *By knowing the Moon's Age, and the Time of High-Water in any Place; to find how it flows Full and Change of the Moon in that Place.*

Rule. Subtract the Moon's Southing from the given Time of High-Water, (if you can: If not, add 12 Hours to the Moon's Southing and subtract

tract;) and the Remainder shews the time answering the Point of the Compass, that makes full Sea, upon the Change or full Days of the Moon.

Example. Admit I was at *Bristol*, and observ'd 'twas High-Water at 45 Minutes after 2 a Clock; the Moon being 25 Days old, or her Southing 8 Hours: How does it flow there Full and Change of the Moon?

$12^h. + 2^h, : 45^m = 14^h. : 45'.$ — Moon Southing $8^h. : 00^m.$ is $= 6^h : 45^m.$ or E. b. S. and W. b. N. it flows there Full and Change of the Moon.

The Sea hath Fits, alternate Course she keeps,
From Deep to Shore, and from the Shore to Deeps.
Whether it were, that at the first the Ocean
From God's own Hand receiv'd this double Motion,
By Means whereof, it never resteth Stound,
But (as a turning Whirly-gigg) goes round,
Whirles of it self, and a good while after takes
Strength of the Strength which the first Motion makes.
Or whether *Cynthia*, that with changeful Laws
Commands moist Bodies, doth this Motion cause:
As on our Shore, we see the Sea to rise,
Soon as the Moon begins to mount our Skies.
And when thro' Heav'ns Vault vailing toward *Spain*
The Moon descendeth; then it ebbs again.
Again, so soon as her inconstant Crown
Begins to shine on th'other Horizon,
It flows again: And then again it falls
When she doth light th'other Meridionals.

15. *By having the Time of the first New Moon in January, all other Aspects of the Moon and Sun may be collected throughout the whole Year: Thus,*

	Days.	ho.	′.	″.
Jan. 1. The Moon being New or ☌ her Age	00	00	00	00
For the: Sextile Aspect ✶ take	04	22	07	20
First Square □	07	09	11	01
Triangle Aspect △	09	20	14	41
Full Moon or ☍ Opposition	14	18	22	02
Full Moon's Triangle △	19	18	22	02
Second Square □	22	03	33	02
Second Sextile ✶	24	14	36	42
Other N. Moon ☌ or Conjunction	29	12	44	03

When the Moon becomes visible after she is in Conjunction with the Sun, then she makes her Effects manifest.

Whence this Proverb;

As is the fourth and fifth Day's Weather,
So's that Lunation altogether.

Or thus; the noble Lord Dubartas.

By Sol's Aspect, her own she daily makes,
She Wax-less, Wane-less, doth both wain and wex.
And, tho' to us she seem a Semi-Ray,
Her full round Face doth never fall away.
By his fair Beams, as well by Day as Night,
The full whole half of her thick Orb is bright.
And as she draws near or far-off from him,
So more or less our half is clear or dim.

Her upper-half is full in her Coition,
Her lower-half is in her Oppoſition;
Her other Quarters other Form expreſs,
And up or downwards ſhew her more or leſs.
When we ſee little, then the Heav'ns have ſtore;
When Heavens ſee little, then have we the more:
Nearer the Sun the leſs ſhe ſeems in Sight,
Turning her Horn ſtill to her Oppoſite.
At Evening increaſing ſhe the Sun ſucceeds,
At Morn decreaſing ſhe her Car preceeds.
So that each Month the Sun environs her,
On every Side his Splendor to confer.
Her Silver Light then only faileth her,
When the Earth's between them (in Diameter)
Which hides her Beauty with a ſable Cloud,
From Light of him her Brother, Golden-brow'd.
Good Lord! what Changes doſt thou work by theſe,
Varieties, in Air, in Earth or Seas.
Fair, or foul Weather. Wind, or Wet, or Thunder,
To dry, or drip, or cold, or warm her-under.
If ſhe but ſmile the fourth Day 'twill be fair,
If then ſhe bluſh, we ſhall have bluſt'ring Air:
If then her Brows be muffled with a Frown,
Moſt of that Month ſhall ſad tears trickle down.
Thus doth the Vigour of the Signs Superior,
Rule in the Virtues of the Things Inferior:
But all are govern'd by God's Soveraign Might,
O! happy he who underſtands it right.

For the Courſes and Diſtances from Place to Place in Coaſting; Sailing into Harbours, *&c.* See the *Coaſting Pilots*, ſold by moſt Stationers, Bookſellers, and the Author and Proprietors of this Book.

The

The Compleat

Modern Navigator's Tutor:

OR

NAVIGATION

IN ITS

THEORY and CURIOSITY.

PART II.

Teaching in a

Plain, conciſe, and regular Method, to ſolve all the Caſes in Plain Sailing; Traverſe, Mercator's, Sailing, Parallel and Middle Latitude, Sailing; Oblique Plain Sailing, (and in Sailing or turning to Windward, in a Current or Tide's Way;) Geometrical, Trigonometrical, Arithmetical, Inſtrumental, and by Inſpection in Tables; together with the Conſtruction and Uſe of the Plain and *Mercator*'s Charts, the Practical Problems in Aſtronomy, relating to the Sun and Stars; Deſcription and Uſe of the Azimuth

Compaſs; to find the Variation of the Compaſs ſeveral Ways: The Deſcription of the Sea-Quadrant Foreſtaff, Backſtaff. To take and work an Obſervation, by the Sun or Stars: With a Catalogue of ſeveral eminent Stars, coming to the Meridian throughout the Year; the Deſcription and the Uſe of the Nocturnal, in finding the Latitude by the Pole Star, *&c.*

CHAP. I.

Theoretical NAVIGATION.

THE proper great or foreign *Navigation*, or the Art of Traverſing and Caravanning over *Neptune*'s vaſt Dominions, is not a ſimple or ſingle Science; but a Complication of the three moſt noble Liberal Sciences, *Arithmetick*, *Geometry*, and *Aſtronomy*. It makes Uſe of *Arithmetick* for Computation or Calculation; *Geometry* for Delineation and Demonſtration; and *Aſtronomy* for Obſervation. (For the firſt of theſe, *viz.* *Arithmetick*, either common, in Vulgar and Decimal Fractions, Logarithmetical and Inſtrumental, I refer the Learner to my *Engliſh Academy of Sciences*, as likewiſe for *Geometry* and *Trigonometry*:) I ſhall only here begin with a few neceſſary *Geometrical* Problems, and the Elements of Plain *Trigonometry*.

Prob. 1. *To biſect or divide a Line, as* A B *into two equal Parts.*

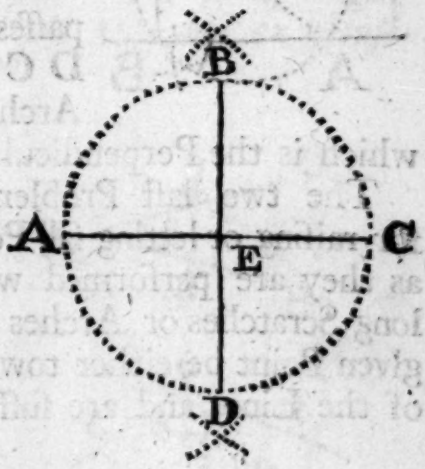
Conſtruction. Set one Foot of the Compaſſes in A, and with any Extent above half the given Line ſtrike

ſtrike two ſmall Arches, the one above, and the other below as **C** and **D**; then with the ſame Extent ſetting one Foot in **B**, croſs the two former Arches in **C** and **D**; then draw the Line **C D** which will divide **AB** into two equal Parts in the Point **E**, as was to be done.

Prob. 2. *To croſs a Circle at right Angles or to quarter a Circle, as* **ABCD.**

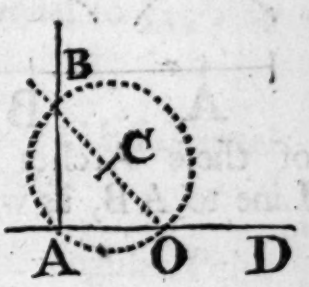
1. Thro' the Center E draw a Diameter **AC.**

2. Divide the Diameter or Line **AC** into two equal Parts by the laſt Problem, and and it's done.



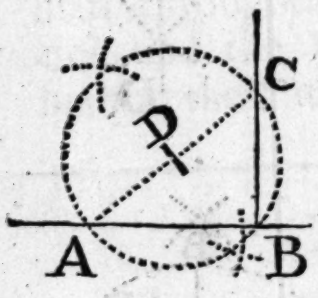
Prob. 3. *From a Point in a given Line either in the Middle or End thereof to raiſe or erect a Perpendicular. Let* **AD** *be a Line given, and* **A** *the Point aſſigned.*

Conſtruction. Fix one Foot of the Compaſſes on any convenient Point as **C**, extending the other to **A**, then turning them, with that Foot at **A** make an Arch at **B**, and another at **O** to croſs the Line



A,B: Then lay a Ruler over O and C, and draw a Line, cutting the Arch B in B. Laſtly, draw A B, which will be a Perpendicular W. W. R.

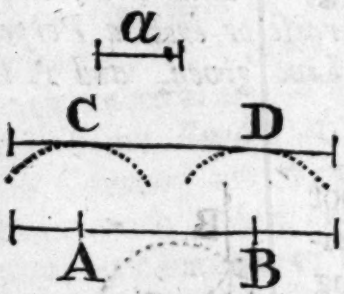
Problem 4. *From a Point aloft (as* C*) to let fall a Perpendicular upon a given Line (as* A B*) is propoſed.*



Conſt. From C, draw a Line C A, (cutting A B in A) which Line divide into two equal Parts in E by *Prob.* 1. Then one Foot of the Compaſſes in E, at the Extent D C or D A, deſcribe an Arch C B. Laſtly, Draw C B, which is the Perpendicular required.

The two laſt Problems are the beſt Methods for raiſing or letting fall Perpendiculars; foraſmuch as they are performed without making many, or long Scratches or Arches; and they hold, let the given Point be either towards the Middle or End of the Line, and are ſufficient for any Uſe.

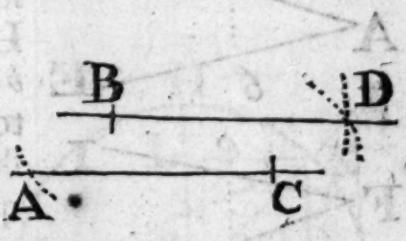
Prob. 5. *To draw a right Line* C D *parallel to a right Line* (A B) *given at any Diſtance* (*a*) *aſſigned.*



Conſt. With the aſſigned Diſtance (*a*) ſetting one Foot in A, deſcribe the Arch C; again, ſetting one Foot in B, deſcribe the Arch D. Laſtly draw a Line to touch the Tops of theſe Arches as C D, which is the parallel Line to A B, as was required.

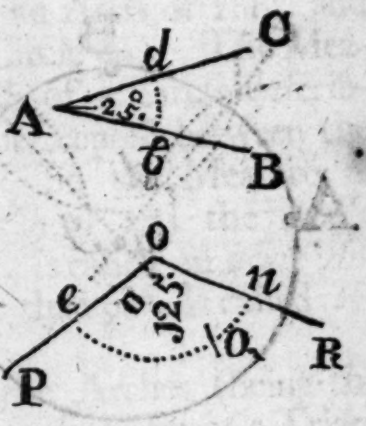
Prob.

Prob. 6. *To draw a right Line* (B D) *parallel to a right Line* (A C) *given, that ſhall paſs thro' a given Point* B.



Conſt. Take the Diſtance B A, and ſetting one Foot in C, deſcribe the Arch D. then with the Extent A C, and one Foot in B, croſs the Arch D. in D. then draw BD, and it's the Parallel required.

Prob. 7. *To ſet off or deſcribe any plain Angle, as ſuppoſe an acute Angle of* 35°. *and an obtuſe Angle of* 125°, *is required.*

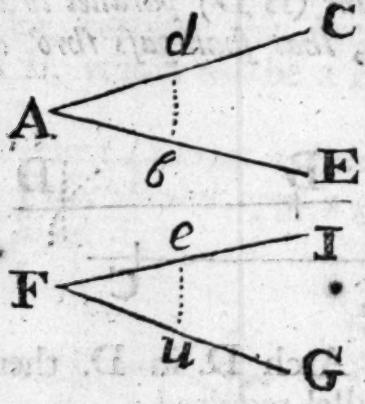


Conſt. 1. Draw the Line A B, and with a Chord of 60°. and one Foot in A, deſcribe an Arch *b d*; make *b d* equal to the Chord of 35°. and draw the Lines A, *d*, C, and it's the acute Angle required.

2. Draw the Line P O, and with a Sweep (or Chord) of 60°. and one Foot in O deſcribe an Arch *e*, *n*, then ſet off a Quadrant, or Chord of 90°. from *e* to Q on this Arch, and the Reſidue, *viz.* the Chord of 35°. from Q to *n*, and draw the Line O, R, which forms the obtuſe Angle P O R, equal to 125°. as was requir'd.

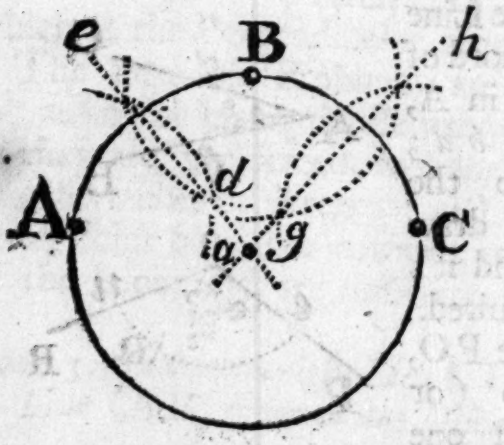
Prob. 8. *To make an Angle (as ſuppoſe* G F L,) *equal to an Angle* (E A C *given.*

Conſtr. Setting one Foot in the angular Point A, with any Extent as A *d*, deſcribe the Arch *b*, *d*;



b, *d*; then with the ſame Extent ſetting one Foot in F deſcribe an Arch *u e*. Laſtly, Take the Extent *b d*, and prick it from *u* to *e*, and draw F I which ſhall make an Angle equal to the Angle C A E as was to be done.

Prob. 9. *To deſcribe the Circumference of a Circle that ſhall paſs through any three Points not ſituate in a right Line.*

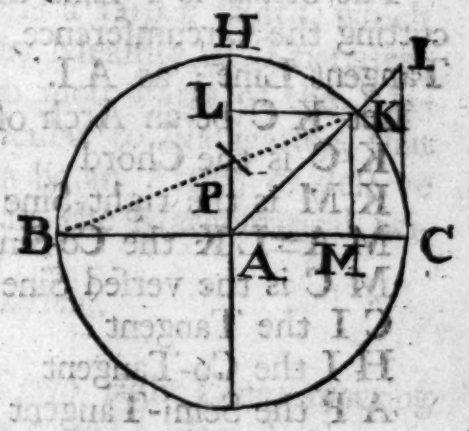


Conſt. Suppoſe A B C, to be the three Points.

1. Take more than half the Diſtance A B, and with one Foot in A ſweep an Arch; then with the ſame Diſtance, and one Foot in B, draw another Arch to croſs the aforeſaid Arch in the Points *d* and *e*. *Secondly*, With more than half the Diſtance B C, and one Foot in B, draw the Arch *g h*, and with the ſame Diſtance, and one Foot in C, draw an Arch to croſs the aforeſaid Arch in the Points *g* and *h*. Then, *Thirdly*, draw the Lines *e d a*, and *h g a*, and where theſe Lines croſs, or interſect each other, as at *a*, is the Center of the Circle required. After the ſame manner, you may deſcribe a Circle about any Triangle.

Prob. 10.

Prob. 10. *Of the Circle.*



The $\frac{1}{360}$ Part of the Circumference of a Circle is called a Degree, each of which is again ſubdivided into ſixty equal Parts called *Minutes*; each of which again is imagined to be divided into 60 equal Parts, called *Seconds*, *&c.* to *Tenths*.

A Semicircle therefore is an Arch of 180°. and a Quadrant or $\frac{1}{4}$ Part of a Circle 90°. The Meaſure of an Angle is the Arch of a Circle deſcribed on the angular Point, intercepted between the Sides ſufficiently produced: So the Meaſure of the right Angle is always 90°. and the Angle which contains leſs than 90°. is called an *acute Angle*, but that which is more than 90°. is called *obtuſe*.

The Proportion, which the Arches (being the Meaſures of Angles) have to the Sides of a Triangle, cannot be certainly known, unleſs by a comparing of Arches with their terminating ſtrait Lines, as Chords, Sines, Tangents, half Tangents, Secants, and verſed Sines.

A Chord is a right Line ſubtending an Arch as C K.

A Sine is half the Chord of the double Arch, as K M.

A Tangent is a Line touching the Circle in ſome Point, as I C.

The

The Semi-Tangent is not half the Tangent of an Arch, as ſome take it to be, but is the Tangent of the half Arch, as A P.

The *Secant* is a Line drawn from the Center, cutting the Circumference, and is extended to the Tangent Line; as A I.

Let K C be an Arch of 45° then

K C is the Chord
K M is the right Sine
M A=L K the Co-Sine
M C is the verſed Sine
C I the Tangent
H I the Co-Tangent
A P the Semi-Tangent
} of 45°.

A K=A C=H A=B A=C I, the Sweep of the Circle, called the Radius, or Semi-diameter. *Note*, that the Secant of 60 is equal to the double Radius.

Such Proportion as the Circumference of one Circle has to another, ſuch proportion have their Degrees, Semi-diameters, Sines, *&c.* of like Arches one to another, and the contrary.

Aſſigning the Radius A C to be a Unit with Cyphers at Pleaſure, to expreſs the Quantities of theſe reſpective Lines, in relation to the Arches to which they belong, is to make a Table of natural Sines, Tangents, and Secants, (for which, and making the Artificial Sines, Tangents, *&c.* ſee my *Logarithmetick Arithmetick*; and alſo for the Geomet. Conſt. of the Natural Sines, Tangents, *&c.* I refer you to my *Plain Trigonometry* in the *Engliſh* Academy.) And I ſhall here only inſert the principal Rules in plain, or right-lined Trigonometry, in order to the Solution of the Problems in Navigation, which wholly depend thereon.

2. *The*

2. *The Elements or Principles of* Trigonometry *Rectilinear.*

And 1. *Trigonometry* is a Greek Word, which ſignifies the Meaſure of Triangles; a Science ſo neceſſary to moſt Parts of the Mathematicks, and in particular to Navigation, that without it no Man can be an Artiſt, or deſerve the Name of Learned in the Mathematical Sciences.

Definitions.

1. The Inclination of two right Lines meeting or cutting each other, is called a plain Angle.

2. That an Angle is ſaid to be greater or leſs than another, according as the ſaid Arch contains more or leſs of the equal Parts which that Circumference is divided into.

3. A plain Surface, terminated by three right Lines, is called a plain Triangle.

4. Triangles are either Right or Oblique angled.

5. The Triangle that has one Angle 90° (or a Perpendicular raiſed or let fall in it) is called a right-angled Triangle.

6. The Triangle that has no Angle of 90°, (or Right-Angle) is an oblique-angled Triangle.

7. A plain Triangle has 6 Parts, *viz.* 3 Sides, and 3 Angles; whereof any three being given (except the Angles) the other three may be found.

Lemma.

In all plain Triangles, the Sum of the three Angles is equal to a Semicircle, or 180°

Corollary

Corollary 1.

Whence in a right-angled plain Triangle, because the right Angle is always 90°, the Sum of the other two Angles is alſo 90°; and therefore ſubtract the acute Angle given from 90°, the remainder is the other acute Angle.

Coroll. 2.

In any oblique plain Triangle, having two Angles given, their Sum ſubtracted from 180, is the other Angle required.

Prop. 1. *Given oppoſite Sides and Angles.*

Rule of Sines.

1. As any one Side is to the Sine of its oppoſite Angle; ſo is any other Side to the Sine of its oppoſite Angle.

2. As the Sine of any one Angle is to its oppoſite Side; ſo is the Sine of any other Angle to its oppoſite Side.

Note; If an Angle be required, let the Proportion begin with a Side: But if a Side be required, then begin with an Angle.

Prop. 2. *Given two Sides, and the contained Angle.*

Caſe 1. If in right-angled Triangles, (as in *Caſe 6, of plain Sailing.*)

Rule 1. *Of Tangents.*

As one Side is to Radius, or Tangent 45°; ſo is the other Side to the Tangent of its oppoſite Angle.

Note,

Note; If an Angle be required, let the Proportion begin with a Side: But if a Side be required, then begin with the Radius.

Case 2. If in oblique-angled Triangles.

Rule 2. *Of Tangents.*

As the Sum of the Sides, containing any Angle, is to their Difference; ſo is the Tang. of ½ the Sum of the unknown Angles, to the Tang. of ½ their Difference.

Then ½ the Difference, added to the ½ Sum, is the greater Angle required. And the ½ Difference ſubtracted from the ½ Sum is the leſſer Angle required.

Prop. 3. *Given the three Sides.*

Rule. As the Baſe, or longeſt Side, is to the Sum of the other Sides; ſo is the Difference of thoſe Sides, to the Difference of the Segments of the Baſe.

Then ½ the Difference, added to ½ the Baſe, is the Baſe of the greater right-angled Triangle; And ½ the Difference, ſubtracted from ½ the Baſe, is the Baſe of the leſſer right-angled Triangle. Whence you have enough given to find what is required by Propoſition 1.

From theſe three Propoſitions, Canons, or Proportions are eaſily formed, for all the Caſes that can happen in plain Sailing, Traverſe, oblique, and *Mercator*'s Sailing, as ſhall be ſhewn.

But firſt, to find the Logarithm of any Number, (Suppoſe 74 Miles, Leagues, *&c.*) look under Title *N.* (for Number) in the Table of Logar. N° 5. for 74; againſt it on the Right-hand is (1,869231) the Logarithm ſought: And *contra*, to find the Number of Miles anſwering to any Logarithm (when wrought) as ſuppoſe

poſe this, 1,897627. Look for theſe Figures in the aforeſaid Table, and againſt them on the Left-hand ſtands 79, the Miles, Leagues, &c. ſought.

2. *To find the Sine, Tangent, or Secant of any Degrees and Minutes.*

Suppoſe of 34°, Look in the Table (N° 6.) for 34 *D.* on the Left-hand, and againſt it, on the Right-hand, ſtands Natural Sine, 55919, Natural Tangent, 67451, Natural Secant 120622; Logarithmetical Sine 9.747561, Log. Tang. 9.828987, Log. Secant. 10.081426. And *contra.* To find the Degrees anſwering to any Natural or Logarithm Sine, Tangent, or Secant. Seek the neareſt Figures in the Table under its proper Title; and on the Left-hand you have the correſpondent Degrees: The ſame is to be underſtood of Points and Quarter-points of the Compaſs in the next Table, the Literal Figures being the whole Points, and the Numerical Figures quarters of a Point.

3. *To work a Proportion or Canon, by the Logarithms, Sines or Tangents, obſerve this general Rule for the artificial ones,* viz.

Add the Logarithm of the ſecond and third
From the Sum ſubtract the Logar. of the firſt } *Term.*
The Remainder is the Logar. of the fourth

4. *To work a Canon or Proportion by* Gunter's *Scale.*

General Rule.

The Extent of the Compaſſes from the firſt to the

ſecond / third	will reach from the	third / ſecond	to the fourth Term required.

Note,

Note, If there be a Tangent in the Proportion, then the Radius is the the Tangent of 45°. and when there is a Secant mention'd, the Operation cannot be perform'd by the Scale.

These things being premiſed, I ſhall proceed to ſhew the General Axiom, *viz.*

In all Right-angled plain Triangles, if one ſide be made the Radius (or Sweep of a Circle) the other Sides will be Sines, Sine Complements, Tangents or Secants, as is evident from the Diagram Page foregoing; for ſuppoſe in the Diagram the Triangle **AIC**, here the Side **AC** is Radius, and the Angle at **A** 50°. The Side **CI** the Tangent of 50°. and the Hipothenuſe **AOI** is the Secant of 50°. and what Proportion the Radius hath to the Side **AC**, the ſame Proportion hath the Tangent of 50° to the Side **CI**; and the ſame Proportion hath the Secant of 50° to the Hipothenuſe **AI**, (as is demonſtrated in my *Trigon. in* the *Eng.* Acad.)

Again, if you make the Hipothenuſe the Radius, and ſuppoſe the Angle at **A** 50° as before; then in the Diagram it is repreſented by the Triangle **AMK**, and then the Side **MK** is the Sine of the Angle at **A**; and the Side **AM** equal to **LK** is the Sine Complement (to 90°.) of the Angle **A**; and then what Proportion the Hipo. hath to Rad. the ſame Proportion will the Side **KM** have to the Sine of 50°.; and the ſame Proportion will the Side **AM** have to the Sine Comp. of 50°, *&c.* And from this Proportion proceeds Prop. foregoing. The Application of all which we come now to ſhew in *Navigation.*

Three General Definitions and Primary Rules.

1. *NAVIGATION* is an Art that teaches how to conduct a Ship through the Pathleſs Ocean (where nothing is ſeen for ſeveral Days but Sky and Water) from one Port or Place to another, the ſhorteſt Way, and in the ſhorteſt Time poſſible, to any part of the known World; or briefly,

Navigation is an Art that teacheth thee
To direct a Ship through the untrack'd Sea,
To any Port or Place where e'er it be.

Navigation may therefore be divided into two General Branches, or Parts, *viz.* Domeſtick, or Home *Navigation*; which is the Coaſting or Sailing along Shoar, in Places not far diſtant, and in ſight of Land or Soundings, as between *England*, *Holland*, *France*, *&c.* for the Performance of which there is required the Compaſs, the Sounding-Lead, and Line, with a competent Knowledge of the Nature of the Lands, or Coaſt, the Soundings, Sands, Shoals, Rocks, *&c.* with the Knowledge of the Setting, Flux and Reflux of the Tides, (of which I have treated on before).

2. *Remote*; which more properly is called *Navigation*, is that whereby the induſtrious Mariner directs the Ship to any Port in the habitable World, and knoweth at any time, in what Place the Ship is in, in reſpect to Latitude, Longitude, Courſe, or Diſtance; the Inſtruments that are uſed in this Art are, therefore, of two Sorts, *viz.*

1. A pair of Compaſſes,
A plain Scale,
A *Gunter*'s Scale.
The plain and *Mercator*'s,
(or *Wright*'s) Charts,
} for Operation.

2. A

2. A plain (or common) Compaſs,
An Azimuth Compaſs,
A Sea Quadrant,
A Fore-ſtaff,
An *Almicanter*'s Staff,
A Log and Line and ½ Min. Glaſs,
} for Obſervation.

That is, the inſtruments for directing and meaſuring the Ship's Way and Courſe ſteered; ſuch as the Log and Line, and ½ Minute Glaſs and Compaſs. Secondly, Inſtruments for Celeſtial Obſervation, ſuch as the Quadrant, Fore-ſtaff, Azimuth, or Amplitude Compaſs, to meaſure the Heights, Diſtances, Azimuths and Amplitudes of the Sun and Stars, and finding the alteration, or Difference of Latitude, thereby to correct the Reckoning by Account, commonly call'd the Dead Reckoning; when there hath been any Error contracted either in the Courſe ſteer'd or the Diſtance ſailed: Likewiſe Charts for pricking down the Ship's Way and Place; which gives a lively Repreſentation where the Ship is at any Time. Thirdly, A competent Knowledge of the Nature of Currents, and of the Trim and Mould of the Ship, and the Sail ſhe bears, Drift, Growth or Surge of the Sea, that ſo due Allowance may be made for Lee Way, and other Impediments. 4thly, Skill in the Navigator; ſo that by the Help of theſe, he may be able to know at all times the Place the Ship is in, how far ſhe hath to ſail, and which way, and upon what Point of the Compaſs her Courſe is to gain her intended Port.

For the obtaining of which, the Mariner hath generally theſe things given;

1. The Latitude and Longitude both of the Place he is to ſail from, and bound to, found in the Tables of Latit. and Longit. of Places, by the Help of which may be found (by the the firſt Caſe of

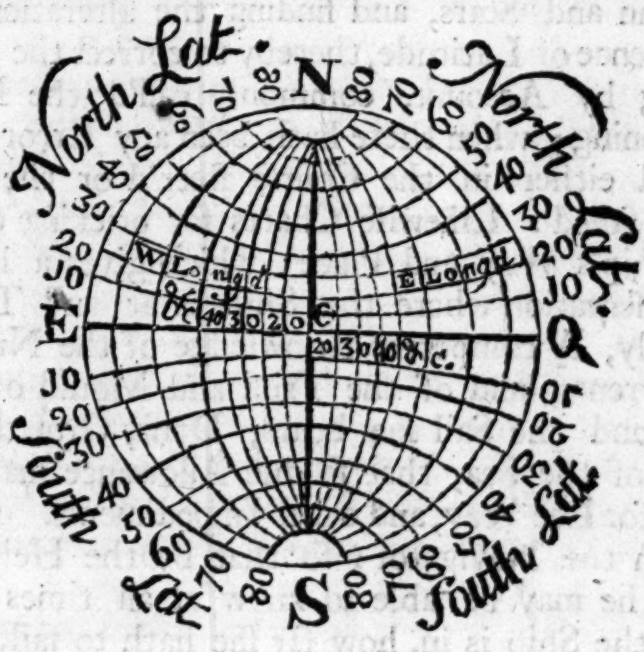
Mercator's Sailing) upon what Course, and how far the Ship must sail.

The Way obtain'd by the Log and Compass.

2. The Latitude of the Place the Ship is in by Observation taken with a Quadrant or Foreſtaff; the Height of the Pole, by the Altitude or Distance from the Zenith of the Sun or a Star.

How to order and manage these, so as to produce the necessary *Quæsita*, we come now to shew.

A Scheme or Projection of the Meridians or Parallels of the Globe in Plano, exhibiting how Latitude and Longitude is accounted.



Explanation.

Let the Circle E N Q S represent the Compass of the terraqueous Globe; and let N be the North-point or Pole; S the South Pole; the Circle N Q S N the General Meridian; and let N S, one Diameter, represent the first Meridian passing over *London*; and imagine a Line to begirt this Globe round equi-distant from the North and South Poles, as E Q, it's call'd the (Equinoctial or) Equator.

tor. Again, imagine Circles to paſs from one Pole to the other through as many Degrees or Points of the Equinoctial as you pleaſe, as N 10. S, N 30 S, *&c.* theſe Circles are called Meridians, upon which Latitude is accounted from the Equator both ways, to the North and South Poles to 90, and the Circles 10, 10 20, 20, 30, 30. parallel to the Equator, are called Parallels of Latitude. On the Equator we count the Longitude, from the Center C, (repreſenting the firſt Meridian or *London*) increaſing Eaſterly 180°, and Weſterly 180° from the ſaid Meridian, till the Account ends in the oppoſite Meridian, on the other ſide of the Globe.

The Diſtance of any one Place from another is the ſhorteſt Line intercepted between theſe two Places, upon the Surface of the Earth: Hence then, as the terraqueous Globe is a round Body or ſpherical (as I have elſewhere demonſtrated) all Lines drawn upon the Surface thereof muſt be ſpherical, or Arches of a Circle, and therefore the Diſtance between any two Places muſt always be an Arch of a Circle; tho' indeed a ſmall Part of of our Globe, (it being of ſo great a Magnitude in the whole) differs not to our Senſe from a Plain, and the Diſtances of two Places not far diſtant, as a Right-line.

Obſervation 1.

Nature herſelf has placed no particular Beginning or Term of the Earth's Extention from Weſt to Eaſt, or from Eaſt to Weſt, (or according to the Equator) hence any of the Meridians may be taken for the firſt Meridian or Beginning of Longitude. Every Superficies, whether plain or curved, is determined and meaſured by two Diviſions, or Extentions; of which Extenſions, the one is called the Length or Longitude of that Figure, or Superficies, and the other the

Breadth or Latitude thereof; but the Figure of the Earth being ſpherical, the Dimenſions thereof are equal; and ſo the Length and Breadth, or Latitude and Longitude muſt not differ, but only according to our Conceptions, that theſe two Terms may be more obvious to us: For ſeeing that the Meridians do all meet in the Poles of the Earth, which are always a Semicircle, or 180°. aſunder from each other, this Semicircle we will take for one of the Earth's Dimenſions. And ſeeing the Equator, equi-diſtant every where from theſe two Poles, is continued without interruption, to a whole Circle (or 360°) we will take this for the other Dimenſion of this ſpherical Surface; this being a whole Circle, is longer than the other, being only a ½ Circle; therefore the Equator muſt be the Meaſure of the Earth's Length or Longitude, and the Meridian the Meaſure of its Breadth, or Latitude.

Obſervation 2.

The Circle you ſee in a clear Day, where the Sky and Sea ſeems to meet all round, is called the ſenſible or viſible Horizon; parallel to which, at the Diſtance of the Earth's ½ Diameter, is the true Horizon.

3. The Point in the Heavens directly over your Head, in all Places is called the *Zenith*; and the Point under the Feet is called the *Nadir*, and are each of them 90°. from the Horizon.

Now, if we imagine Circles to be deſcribed in the Heavens round the Globe, all meeting in the Zenith and Nadir, as the Meridians do in the Poles, and to cut the Horizon at right Angles, as the Meridians do the Equinoctial.

Theſe Circles are called Azimuths, in which the Sun is every Minute of the Day, except at Noon when he is on the Meridian.

4. And

4. And if there be imagined Parallels to the Horizon upwards towards the Zenith, they are called Almicanters, or Circles of Altitude, or Height of the Sun and Stars above the Horizon.

5. Amplitude of the Sun or Stars is their Distance from the East Point of the Horizon to the Northward, or Southward of their Rising, and from the West Point, Northerly or Southerly at their Setting; according as the Sun or Star is to the Northward or Southward of the Equinoctial.

Of Course.

The Rhumb, or Course, is the Point of the Compass which a Ship sails on, reckoned from the North and South towards the East or West; and the Complement of the Course is the Point of the Compass steered, reckoned from the East and West, towards the North or South, or the Residue, (or Complement) of the Course, when taken from 90°.

Of Distance.

Distance is the Number of Miles, or Leagues, the Ship sails upon any Course or Point of the Compass.

Of Difference of Latitude.

Difference, or Alteration of Latitude, is the Difference between the Latitude sailed from, and the Latitude the Ship is come into.

Of Departure, or meridional Distance.

Departure, or meridional Distance, is the Number of Miles the Ship hath made East or West, from the Meridian (or North and South Line) she departed from.

Primary Problems.

Prob. 1. { Given the Latitude of two Places. Requir'd the Difference of Latitude between them.

Rule 1. If the two Places are on the ſame ſide of the Equator, (that is, both in North or both in South Latitude) their Difference is the Difference of Latitude required.

Rule 2. If the Places are on the contrary ſide of the Equator, (that is, one in North, the other in South Latitude) their Sum is the Difference of Latitude.

Examp. 1. What's the Difference of Latitude between the *Lizard* and *Madera*?

From } the Lat. of { *Lizard.* 49° : 56′ N. 17° : 31′
Subt. } { *Madera* 32 : 25 N. 60

Remaind. is the Diff. of Lat. = 17 : 31, or 1051 miles.

Examp. 2. What's the Difference of Lat. between St. *Jago*, one of the Iſles of *Cape de Verd*, and St. *Helena*, an Iſland in the *Ethiopean* Sea?

To } Lat. { St. *Jago* — 14° : 56′ N. 30° : 41′
Add } { St. *Helena* 15 : 45 S. 60

The Sum is the Diff. Lat. 30 : 41 or 1841 miles.

Prob. 2.

Given, One Latitude and Differences of Latit.
Requir'd the other Latitude.

Rule 1. The Ship in N°. Latitude.

1. If the Courſe be Northward, ſhe raiſeth, or elevateth the Pole, and increaſeth her Latitude; and therefore the Differences of Latitude, (reduced to Degrees and Minutes) muſt be added to the Latitude from whence the Ship came, and that Sum ſhall be the Ship's Latitude North.

Examp. 1.

Ex. 1. Suppoſe from the Latitude of 32°. 25′. North, a Ship ſails 1051 Miles or 17°. 31′. Northward, what's the Latitude the Ship is in?

			°	′	
To the departed	} Lat.	{	32	25	N.
Add the Difference of		{	17	31	N.
Sum is the Latitude required			49	56	N.

Ex. 2. If from the Latitude 40°. 30′. North, a Ship ſails Southward till the Difference of Latitude be 25°. 15′. what Latitude is ſhe in?

			°	′	
From the departed	} Lat.	{	40	30	N.
Subtract the Difference of		{	25	15	S.
Remainder is the required Latitude			15	15	N.

Note. If the Courſe be Southward, and the Difference of Latitude (reduced to D. and M.) is greater than the Latitude the Ship came from: Subtract the ſaid Latitude from the Difference of Latitude, and the Remainder ſhall be the Ships Latitude South; and conſequently the Ship hath croſs'd the Equinoctial Line, and depreſſed the North Pole, and raiſed the South Pole.

Ex. 3. If from the Latitude of 2°. 20′. North, a Ship ſails Southward till ſhe has differed her Latitude 4°. 30′. what Latitude is ſhe in?

From

		°	′	
From the Difference of —— }	Lat.	4	30	S.
Subtract the departed —— }		2	20	N.
Remainder is the required Latitude		2	10	S.

Rule 2. The Ship in South Latitude.

1. If the Course be Southward, the Ship raiseth the South Pole, or increaseth her Lat. and then the Diff. of Lat. reduc'd into D. and M. must be added to the Lat. she departed from, and the Sum shall be the Ship's Lat. South.

2. If the Course be Northward, she decreaseth her Lat. and therefore the Diff. of Lat. reduc'd to D. and M. must be subtracted from the Lat. she departed from, and the Remainder shall be the Ship's Latitude South.

Note, If the Course be Northward, and the Differences of Latitude be greater than the Latitude the Ship came from: Subtract the said Latitude from the reduced Differences of Latitude, and the Remainder shall be the Ship's Latitude North, and consequently the Ship hath crossed the Equinoctial.

Rule 3. To find whether you must sail Northward or Southward, between any two Places whose Latitudes are known.

1. If you sail from a greater North Latitude to a lesser, the Course is Southward: But if from a lesser North Latitude to a greater, the Course is Northward.

2. If you sail from a greater South Latitude to a lesser, the Course is Northward: But if from a lesser South Latitude to a greater, the Course is Southward.

If

If you ſail from a North Latitude to a South Latitude, the Courſe is Southward; but if from a South Latitude to a North Latitude, the Courſe is Northward.

If a Ship ſails Eaſt or Weſt, ſhe keepeth in the ſame Latitude, and makes no Northing or Southing, but her Diſtance and Departure will be the ſame.

If a Ship ſails North or South, ſhe keeps in the ſame Longitude, and makes no Eaſting or Weſting, therefore her Diſtance and Difference of Latitude is the ſame.

4. *Of plain Sailing, and the plain Sea-Chart.*

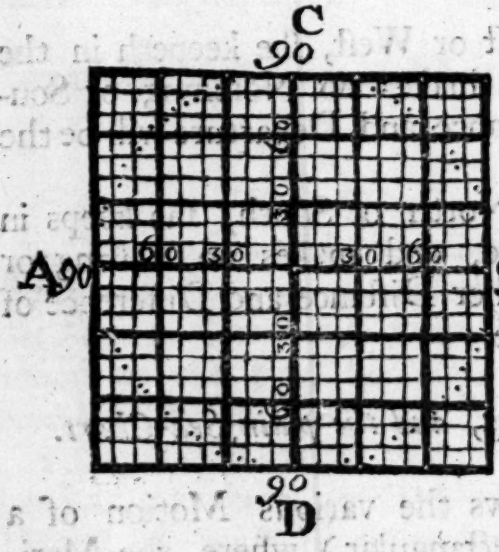
Plain Sailing ſhews the various Motion of a Ship on a Plain (Rectangular) where the Meridians are all made parallel to one another, the Parallels at right Angles to the Meridians, and the Degrees of each, parallel to thoſe of the Equinoctial; in which, though according to this Hypotheſis, each Parallel is falſly ſuppoſed equal to the Equator, and the terraqueous Globe as falſly to be plain or flat; yet ſince a ſmall Part of the Earth's Superficies does differ very little from a Plain; if a Ship ſail under or near the Meridian, or near the Equator, a ſhort Voyage, or a long one cut into many ſhort one's, may be tolerably well performed by it, therefore we ſhall proceed to it's Conſtruction and Uſe.

Of the Conſtruction of the plain Chart.

Theſe Charts are either general or particular.

1. *The*

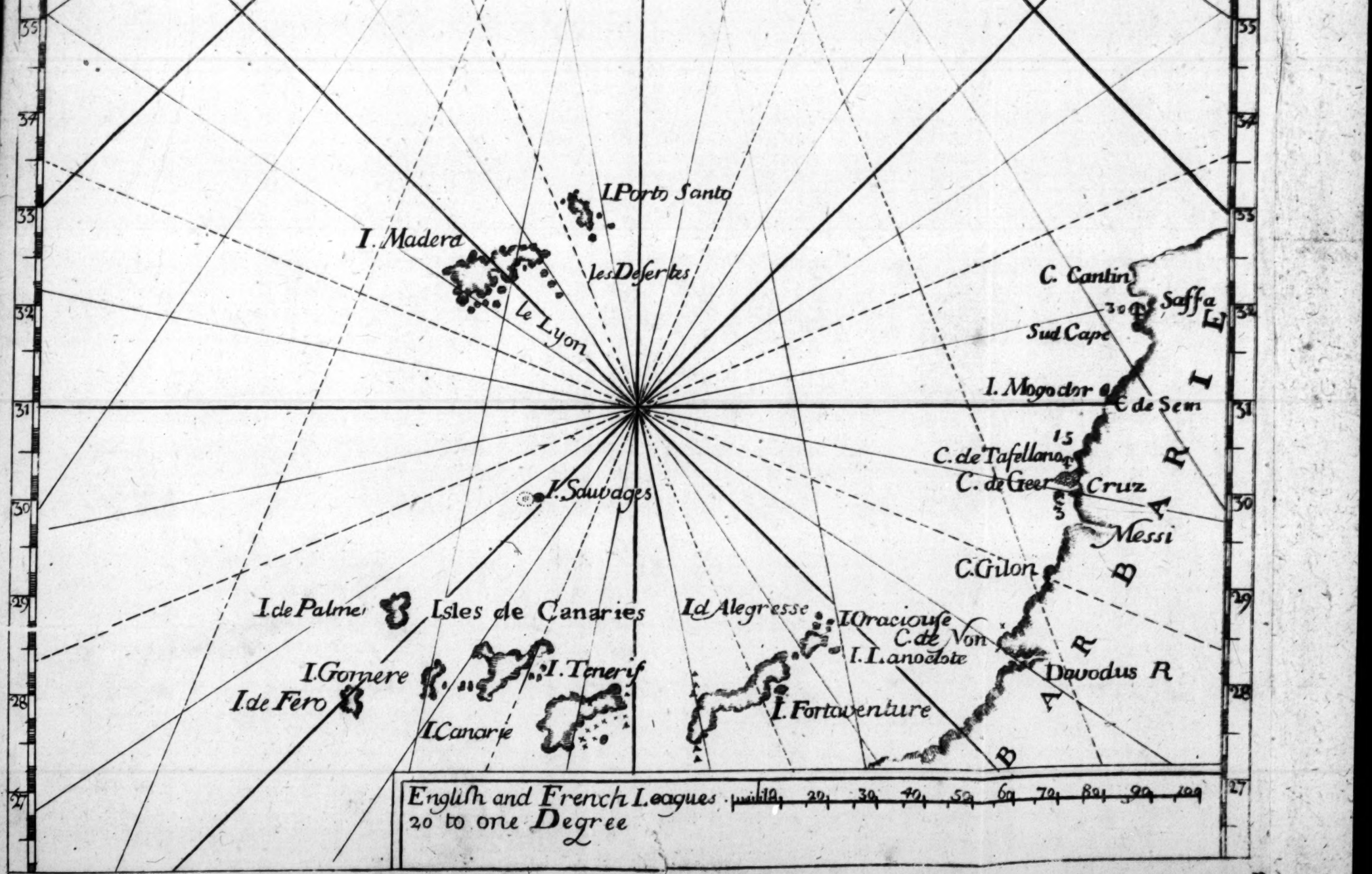
1. *The general plain Chart*

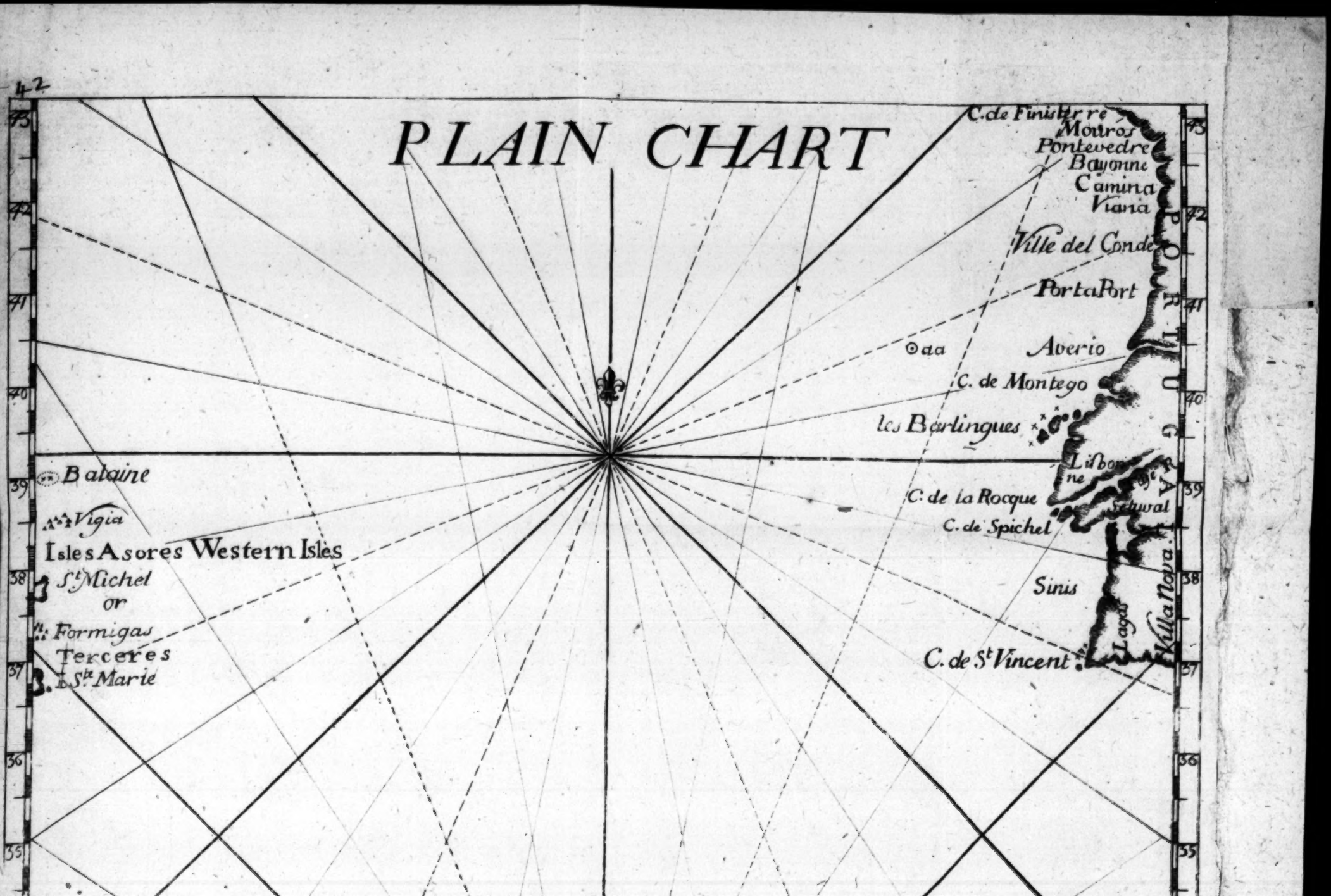


Projection, Draw the Line A B for the Equator; and divide it into 180 equal Parts or Degrees, and through each Degree, or (as here) each 10th Degree, draw perpendicular Lines which ſhall repreſent the Meridians of this Chart. Divide theſe Meridians into 90 equal Parts or Degrees from the Equator, toward the Northward and Southward thereof, and draw Lines parallel to the Equator, which ſhall repreſent the Parallels or Circles of Latitude, as the Meridians did repreſent the Circles of Longitude; upon this Chart then you may by help of a Table of Latitude and Longitude of Places inſert the ſaid Places.

But ſeeing (according to this Chart) that the Meridians have no Inclination to each other, but are all parallel to each other, and divided equally as the Equator; therefore if you inſert theſe Places according to their true Latitudes and Longitudes, then ſhall their Courſe and Diſtance diſagree with the Globe; and if you ſet theſe Places upon this Chart according to their Latitude and Diſtance, then will their Courſe be true, but their Longitude always erroneous, as ſhall be explained in the Uſe of *Mercator's* Chart.

2. The


I. Porto Santo
I. Madera
les Desertes
le Lyon
C. Cantin
Saffa
Sud Cape
I. Mogodor
C. de Sem
C. de Tafellana
C. de Geer
Cruz
Messi
C. Gilon
I. Sauvages
I. de Palme
Isles de Canaries
Id Alegresse
I. Oracioufe
C. de Non
I. I. anoclote
Davodus R
I. Gomere
I. Teneriff
I. de Fero
I. Canarie
I. Fortaventure
BARBARIE
English and French Leagues
20 to one Degree


42
PLAIN CHART
C. de Finisterre
Mouros
Pontevedre
Bayonne
Camina
Viana
Ville del Conde
PortaPort
Averio
C. de Montego
les Berlingues
Lisbonne
C. de la Rocque
Setuval
C. de Spichel
Sinis
Villa Nova
Lagos
C. de St Vincent
PORTUGAL
Bataine
Vigia
Isles Asores Western Isles
St Michel
or
Formigas
Terceres
St Marie
43
42
41
40
39
38
37
36
35

2. The Conſtruction of the particular plain hart is the ſame with that of the general, and iffers only in its Extent, and made generally for ſmall Part of the World; with one or more nall Compaſs, Cards in the Middle or Corners, ſhew by the Rhumbs, or Points of theſe, the earings or Poſition of Places, and alſo a Scale Leagues for meaſuring the Diſtances of Places; ne Meridian is alſo a Scale of equal Degrees, and ay ſerve likewiſe to meaſure the ſaid Diſtances. aſtly, if each Degree of the Meridian is divided to as many equal Parts as its Breadth will ad-it of, the Chart is render'd fit for any manner Uſe that it may be applied to; and

To lay down any Place upon this Chart, by its Latitude and Longitude.

1. Through the Degree in the Meridian anſwer-g to its Latitude, draw an occult Parallel of La-tude.

2. Lay a Ruler over the Degrees of its Longi-de, and draw an occult Meridian; where this ts the Parallel of Latitude before drawn, is the lace required.

By the Help of this, may a Map of any rticular Country, or the Sea Coaſt be drawn, if e Latitude and Longitude of the Places it muſt ntain be known.

2. *To lay down any Place by its Bearing and iſtance from any Place.*

After having found out the Rhumb-line an-ering to the Bearing given, through the Place opoſed, and parallel to the Rhumb, draw a Line d ſet off upon it (from the given Place) the iſtance given in Leagues, or Parts of the gra-

duated

duated Meridian, and the Point thus found will be the Place required.

3. *If the Difference of Latitude and Bearing be given.*

Count the Difference of Latitude either Northward or Southward, (as the Caſe requires,) on the divided Meridian from the given Latitude, and draw the Parallel of Latitude paſſing through the ſame, and lay a Ruler over the Place, and parallel to the Rumb-line given; where it cuts the Parallel before drawn, it gives the Place required.

4. *If it be by the Diſtance and Difference of Latitude.*

Having drawn the Parallel as before, (by the Help of the Difference of Latitude) take the Diſtance between the Points of the Compaſſes, and ſet one Foot in the Place given, and with the other croſs the Parallel before drawn, and you will have the Place requir'd. There are other ways to lay down a Place, as by the Courſe and Departure, or by the Diſtance and Departure; which, as they are of no great Uſe, ſo to avoid Prolixity, I ſhall wave them, and judge it needleſs to illuſtrate theſe Propoſitions by Examples, ſince they are ſo plain and eaſy.

Note, Difference of Longitude, meridional Diſtance, Departure from the Meridian ſignify (in the plain Chart) one and the ſame thing, and is the neareſt Diſtance of any two Meridians; it ſheweth how far one Place is to the Eaſtward or Weſtward of another.

Of the Uſe of the plain Chart, by Examples.

1. To find the Latitude of any Place in the Chart.

Ex.

Ex. *What's the Latitude of the* Lizard *in* England?

1. Take the neareſt Diſtance from the *Lizard* to any Parallel of Latitude, or Eaſt and Weſt Line.

2. Lay that Diſtance (on the graduated Meridian) from the ſaid Parallel, and the moveable Foot ſheweth 50 Degrees North Latitude; becauſe to the Northward of the Equinoctial. Do ſo for any other Place.

2. To find the meridional Diſtance or Differences of Longitude between any two Places in the Chart.

Ex. *What's the meridional Diſtance (or Weſting) from the* Lizard *to* Cape Finiſterre?

1. Take the neareſt Diſtance from the *Lizard* to a Meridian, and moving the Compaſſes with one Foot on it, and the other perpendicular, till both Feet come to the Parallel of *Cape Finiſterre.*

2. Then the Diſtance from the perpendicular Foot to *Cape Finiſterre*, being meaſured on the Meridian, is 3 Degrees, or on the Scale of Leagues 60.

3. To find the Courſe or Bearing of one Place from another.

Ex. *I demand the Courſe from the* Lizard *to the Iſland* Madera?

1. Laying a Ruler's Edge on the Lizard and (the Middle of) *Madera*, and take the neareſt Diſtance from the Center of any Compaſs to the Ruler.

2. Slide the Compaſſes along by the Ruler, keeping one Foot perpendicular to it, and it ſheweth among the Rhumbs the Courſe to be S. S. W. half W. neareſt from the firſt Place to the ſecond.

4. To

4. *To find the Diſtance of one Place from another.*

1. Extend the Compaſſes from one Place to the other.

2. Apply this Diſtance to the Scale of Leagues, or to the graduated Meridian; the firſt ſheweth the Diſtance in Leagues, the latter in Degrees. This is ſo plain and eaſy it needs no Example.

5. *The Latitude the Ship is in, and her meridional Diſtance given; to find in the Chart where the Ship is.*

1. Lay of the Meridional Diſtance (according to its Nature, whether to the Eaſtward or Weſtward) from the Place (you ſail'd) it's counted from; and then the neareſt Diſtance from that to any Meridian muſt be kept in one Pair of Compaſſes.

2. With another Pair of Compaſſes, take the neareſt Diſtance of the Latitude from any Parallel, or Eaſt and Weſt-line.

3. Then move both Pair of Compaſſes perpendicular, one to the Meridian, the other on the Parallel, till both perpendicular Feet meet, and there is the Place in the Chart repreſenting the Place of the Ship required.

By the Help of theſe Propoſitions, may the Mariner diſcover upon what Courſe (if poſſible) and how far he muſt ſail, to arrive at his deſired Port, as alſo to lay down his ſeveral Runnings, and thence find the ſeveral Places he arrives at in the end; and ſo be able to alter his Courſe, of a new, in order to gain any Port in the ſhorteſt Time poſſible.

But, though this Way is very expeditious, and a natural Repreſentation to the Mind; yet I would not adviſe the young Navigator to depend wholly upon it, but rather beſides this keep to his Account

count by Calculation, according to the Methods hereafter ſhewn; and then if at any Time his Curioſity ſhall lead him to examine how exact he has been, will be of great Uſe.

I proceed now to *Theoretical Navigation*, according to all the modern Methods or Improvements. Method the firſt ſhall be *Plain Sailing* projected Geometrically, and wrought by the Logarithms and *Gunter*'s Scale.

CHAP. II.

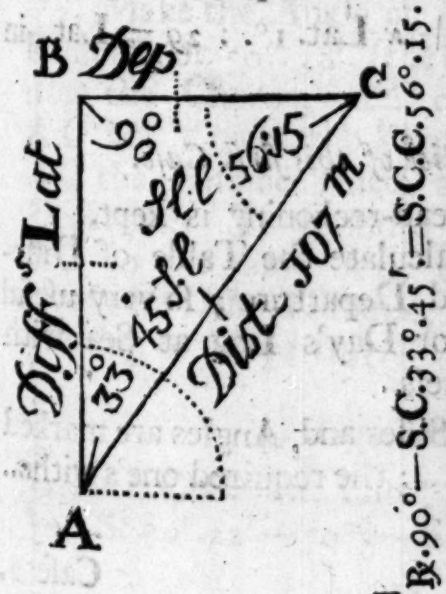
Theoretical NAVIGATION;

Plain Sailing, Method 1.

CASE I.

GIVEN Courſe and Diſtance; required x. *Latitude and Departure: A Ship in the Latitude of* 45°. : 00'. N°. *ſails* N. E. b. N. 107 *Miles, what Eaſting hath ſhe made, and what Latitude is ſhe come into?*

Projection Geometrically.



1. Draw A B for a Meridian or North and South Line. 2. Make the Angle at A = 3 Points = 33°: 45'. from the Line of Rhumbs or Chords on your plain Scale, by *Prob.* 7. *Geom. Prob.* (3.) Draw A C and make it equal the Diſt. 107'. from any Scale of equal Parts. *Laſtly*, From the Point

Point C, let fall the Perpendiculat C B, ſo ſhal A B be the Ship's Alteration or Difference of La titude, and B C her Departure or Eaſting, ∠ A= Sine of the Courſe, and ∠ C, the Sine Comple ment of the Courſe, and ∠ B Radius S. 90°.

2. *Menſuration mechanically.*

A B, and B C being each meaſured on the Scale of equal Parts you ſet of A C by, the firſt give 89^{m} for the Difference of Latitude, and 59^{m}. fo the Eaſting or Departure.

3. *Operation Logarithmetically.*

1. As R. .. Diſt^{s}. : : S. C. C. .. ∠. Lat. Northerly.
——S. 90—107^{m}.—— S. 56°. 15′ ——89^{m}.

2. As R. .. Diſt^{s}. : : S.C. .. Departure Eaſterly.
—— S. 90°.——107^{m}.—— S. 33°. 45′.——59 Miles

3. *Inſtrumental by* Gunter's *Scale.*

1. The Ext. will reach { from R. S. 90. to S. C. C. 56°. 15′ } the { Sine Dif. 107′. to Dif. Lat. 89′ } on the { N^{rs}.

2. The Ext. reaches { from R. S. 90°. to S. C. 33°. 45′. } on the { Sine Diſt^{s}. 107. to Dep^{r}. 59′. } { N^{rs}.

Lat. from 45°. 00′. + ∠ Lat. 1°. : 29 = Lat. in 46°. 29′. North.

Uſe or Practice of this firſt Caſe.

1. By this your Dead-reckoning is kept.

2. By it you may calculate the Table of Diffe rence of Latitude and Departure; ſo very uſefu to work a Traverſe, or Day's Log at Sea with great Eaſe and Quickneſs.

N. B. The given Sides and Angles are marked in the Projections with —; the required one's with

Caſe

Case 2. *Given, Course and Difference of Latitude, required Distance run and Departure. A Ship in the Latitude of* 48°. 30'. N. *sails* N. W. ½ W. (*or* N°. 50°. 38'. W.) *until by Observation, she is in the Latitude of* 49°. 40'. N°. *What is her Westing and Distance run?*

		°	′
Preparation; from the observed Lat.	49	40	
Take the departed Lat.	48	30	
Remainder is the Difference of		1	10
From R		90	00
Take the Sine of the Course		50	38
Remains the Sine-Comp. of the Course		39	22

4. *Geometrically.*

1. Make A B = 70 from a Scale of equal Parts, and (by *Prob.* 3. *Geom.*) raise the Perpendicular B C.

2. Make the Angle at A = 4 ½ Rhumbs, or 50°. 38'. (the Course) from the Chords, and continue A C till it meet the Perpendicular in C. then is A C the Distance sailed, and B C the Westing or Departure. To measure which, apply A C and B C to the same Scale of equal Parts, the first gives 110^m. the Distance, the latter 85^m. for the Westing or Departure.

3. *Logarithmetically.*

1. As S. C. C. .. *x*. Lat. :: R .. Distance.
— S. 39°.22'—70^m.—S. 90°.—110 Miles.

2. As S.C.C. .. *x.* Lat. :: S.C .. Departure.
— S. 39°. 22′.—70^{m}.—S. 50°. 38′.. 85^{m} Westing.

4. *By* Gunter's *Scale.*

The Ext. reaches } from { S.C.C. 39°. 22′. to R. S. 90°. } on the { Sines
{ *x.* Lat. 70^{m}. to Dist^{s}. 110 } { N^{rs}.

The Ext. reaches } from { S.C.C. 39° 22′. to S.C. 50°. 38′. } on the { S^{es}
{ *x.* Lat. 70^{m}. to Dep^{r}. 85^{m}. } { N^{s}

Use. The Navigator must be sure to take an Observation by the Sun or Stars, as often as he has Opportunity, (every Noon and at Night,) and see that the Course be truly steer'd, and then if he finds the Difference of Latitude from Yesterday's Observation disagree from the Difference of Latitude by Dead-Reckoning, found by the first Case: Then let him take the Course steer'd and this observ'd Difference of Latitude, and find the (corrected) Distance and Departure by this second Case of *Plain Sailing.*

Case. 3. *Given, Course and Departure; required Distance and Difference of Latitude.*

Ex. A Ship in the Latitude of 37°. 50′. North, sails S. E. by S. until her Departure or Easting be 75 Miles; what is her Distance run, and the Latitude she is come into?

Geometrically.

1. The Angle of the Course B A C being made equal to three Rhumbs or 33°. 45′.

2. With

2. With the Departure 75m. draw D C parallel to the Meridian A B till it meet the Diſtance A C produced in C the Ship's Place.

3. From the Point C. let fall the Perpendicular B C.

2. *Menſuration.*

A C and A B meaſured on the equal Parts you protracted D C, ſhall give 134m. the Diſtance.
Sailed, and ——————— 112m.

——— = 1°. 52′, the
60

Ship's Diff. Lat. Southerly.

3. *Logarithmetically.*

1. As S. C. .. Depr. :: R .. Diſts.
—S. 33°. : 45——75m.——S. 90°.——134 Miles.

2. As S. C. .. Depr :: S. C. C. .. x. Lat.
—S. 33° : 45′—75m.—56°. : 15′.— 112 Miles.

4. *Inſtrumentally, by* G. S.

The Ext. reaches } from { S. C. 33°. 45′. to R S. 90°. / Depr. 75m. to Diſts, 134m. } on { Sines / Nrs.

The Ext. reaches } from { S. C. 33°: 45′. to S. C. C. 56°: 15′ / Depr. 75m. to x. Lat. 112m. } on { Sns. / Ns.

	°.	′.	
From the Latitude ſail'd from	37	: 50	N°.
Take the Diff. Latitude	1	: 52	Sly.
Remr. is the Ship's preſent Lat.	35	: 58	N°.

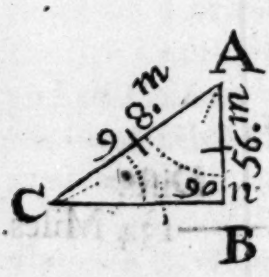
This Case is of little or no Use in Navigation.

Case 4. *Given Distance and x's Latitude, requir'd Course and Departure.*

Ex. A Ship sails between the South and West 98m. from the Latitude of 50°. 00′. and then is in the Latitude of 49°. 04′. (by Observation) what Course hath she steer'd, and what's her Westing or Departure?

Prep. Lat. 50°. 00′. — Lat. 49°. ; 04′ = 56′. or Miles the x^s. or Alteration of Latitude.

Projection Geometrically.



1. Draw A B the Meridian, and set of 56 equal Parts for the x. Lat. from A to B.

2. Because the Course is S°. Westerly, raise the Perpendicular B C, toward the left Hand.

3. With the Distance sail'd, 98 equal Parts between your Compasses, setting one Foot in A, the Place departed from, with the other cross the Perpendicular in C the Place the Ship is in.

Lastly draw A C the Distance.

2. *Mensuration.*

Measure the Arch of the Angle of the Course *n*, 8, on the Chords, and you have 55°. 09′. the Course South-Westerly; also apply B C, to your Scale of equal Parts, and it gives 80 Miles for the Departure or Westing.

3. *Loga-*

3. *Logarithmetically.*

1. As Dist^{s}. .. R$_{x}$ :: x. Lat. S. C. Course.
——98^{m}.—S. 90°.——56^{m}——34°:51′. Which take from 90°. 00′. and you have 55°: 09′. for the Course South-Westerly.

2. As R$_{x}$ .. Dist^{s}. :: S. C. .. Departure
——S. 90°.——98^{m}——S. 55°. : 09—— 80 Miles West.

4. *Instrumental*, by G. S.

The Ext. reaches { from { Dist^{s}. 98 to x. Lat. 56^{m}, / R$_{x}$ S. 90. to S. C. C. 34°, 51′. } on { N^{rs}. / Sines }

The Ext. reaches { from { R$_{x}$ S. 90°, S. C. 55°. 09 / Dist^{s} 98^{m} to Dep^{r}. 80^{m}. } on { Sines / Numb^{r} }

Use. If you mistrust the Care of him that steers the Ship, that he has let her yaw or fall off, or that you have neglected the Variation, or met with thwart Currents, and are assured in your self of having made a good Estimate of the Distance run by the Log: Then with this Distance, and the true x. Latitude by Observation find the Course and Departure by this fourth Case of *Plain Sailing*.

Case 5. *Given Distance run and Departure; required Course and x^{s}. Latitude.*

Ex. A Ship from the Latitude of 40°. 10′. North, sails between the North and East 59^{m}, until her Departure or Easting, be 33^{m}. I demand the Course she hath sail'd, and the Latitude she is in?

Geometrically.

1. Draw the Meridian AB, and erect the Perpendicular BC, which make equal to the Departure 33 Miles = Parts.

2. With the Distance 59 Miles = Parts between your Compasses, and one Foot in C the Ship's Place; the other will cross the Meridian in A, the Place departed from.

Lastly, draw AC the Distance sailed. 2. The Course, and *x*. Lat. AB is measured, as in the last Case; which you will find 34°. or N. E. by N. 15′ Eastwardly, and the *x*. Lat. 49 Miles.

3. *Logarithmetically.*

1. As Dist^{s}. ... R$_{x}$ :: Departure S. Course.
——59^{m}.——S. 90°.——33^{m}.——N. 34°. 00′. East

2. As R$_{x}$ .. Dist^{s}. :: S. C. C. .. *x*. Lat.
——S. 90——59——S. 56°. 00′.——59^{m}. N^{ly}.

4. *Instrumentally, by* G. S.

The Ext. reaches } from { Dist^{s}. 59 to Dep^{r}. 33^{m}. / R$_{x}$ S. 90°. to S. C. 34°. } on { N^{rs}. / Sines.

The Ext. reaches } from { R$_{x}$ S. 90°. S. C. C. 56°. / Dist^{s}. 59^{m}. to Dep^{r}. 33^{m}. } on { Sines. / N^{rs}.

	°	′	
To the Latitude sail'd from ——	40	10	North
Add the *x*^{s}. Latitude ——	00	49	North
Sum is the Latitude the Ship is in	40	49	North

This Case is not of much Use.

Case. 6.

Case. 6. *Given the x^s. Latitude and Departure, required the Course and Distance.*

Ex. Admit a Ship in the Latitude of 43°. 00′. North, is bound to a Port in the Latitude 43°. 52′. North, that lies 33 Miles to the Eastward of the first Port: I demand upon what Course, and how far she must sail to gain her intended Port.

Prep. Lat. 43°. 00′.—43°. 52′.=52^m. *x.* Lat.

2. *Geometrically.*

1. Make A B on the Meridian equal to 52 = Parts, the *x^s.* Latitude.

2. Raise the Perpendicular B C, which make equal to 33 = Parts the Departure.

Lastly, Draw A C, then the Angle, B A C is the Course, and A C the Distance of the Ports, and are measured, as in the 4th Case foregoing.

3. *Logarithmetically.*

1. As *x.* Lat. .. R :: Dep^r. .. Tang. Course.
—52^m.—T.45°.——33^m.——N.32°. 24′.East

2. As S. C. .. Dep^r. :: R .. Dist^s.
——S. 32°. 24′.——33^m.——S. 90°.——61 ½ Miles

4. *Instrumentally, by* G. S.

The Ext. reaches } from { X. Lat. 52^m. to Dep^r. 33^m. T. 45°. to Tang. C. 32°. 24′. } on { N^rs T^rs

The Ext. will reach } from { S. C. 32°. 24′. to R. S. 90°. Dep^r. 33^m. to Dist^s. 61^m. } on { Sines N^rs.

Note

Note, In the firſt of theſe Extentions, if the Departure happens to be greater than the *x^s.* Latitude, you muſt count the Courſe increaſing from Tangent 45°. towards the left Hand, if the *x^s.* Latitude be greateſt as in this Caſe; count it from the left Hand towards 45°. or the right. If the Departure and *x^s.* Latitude are equal Numbers, then your Courſe is always 45°. from the Meridian. I might have given you other Varieties in Calculation, of theſe ſix common Caſes of *Plain Sailing*, as in making each Side the Radius of a Circle, but ſeeing it's of no great Uſe; and having done it in my rectangular *Plain Trigonometry*, I leave it to the Learner's Curioſity to make the Application here.

This ſixth Caſe is of continual Uſe at Sea, when we have corrected our Courſes from the Log, and found the *x^s.* Latitude and Departure made, by the Traverſe Table, to find the Ship's Courſe and Diſtance made good.

Oblique Plain Sailing ſhould follow, but ſeeing 'tis the moſt difficult and leaſt uſeful in Navigation, I ſhall defer treating of it till after *Mercator's Sailing*.

Method 2. By the Traverſe Tables.

Caſe 1. *Given Courſe* N. E. by N. *Diſtance* 107. *Miles, required the Difference of Latitude and Departure?*

BY Inſpection in the T. Table, break the Diſtances into two Parts 100 and 7.

Againſt (the Diſtances) 7 Miles, and under the Courſe (N. E. by N.) or 3 Points, you'll find 5.8 *x.* Lat. and 3.9 Departure. Againſt the (Diſt.) 100 Miles, and under 3 Points you have 83.1

Diff.

Differences of Latitude, and 55.6 Depart. Then,

To *x* Lat. 5.8 —— Depart. 3.9
Add *x* Lat. 83.1 —— Depart. 55.6

The *x* Lat. = 88.9 —— Depart. = 59.5
10 10

which was required.

Case 2. *Given Course* N. W. ½ W. *and difference of Lat.* 70 *Miles: To find the Distance and Departure.*

Take ½ the *x* Lat. $\frac{1}{2}^{a} = 35^{m}$. Over N. W. *viz.* 4 ½ Points, at the bottom of the Table, Titled Lat. find the *x* Lat. 35^{m}. or neareſt to it, which is 34.9. Againſt which, on the left Hand, over Title *Dep.* you have 42.5 Departure. And over Title *Diſt.* on the left Hand 55^{m} Diſtance. The double of each gives Diſt. 110 Miles; and Departure 85 Miles, as was required.

Caſe 3. *Given Courſe* S. E. by S. *and Departure* 75^{m}. *Required Diſtances and x Lat.*

Under (N. E. by N.) 3 Points, and Title *Dep.* find the neareſt N^{r}. to the Departure, which (in Parts) is 55.6. and 19.4. againſt which ſtands *x.* Lat. 83.1. Diſt. 100. and *x.* Lat. 29.1. and Diſt. 35. which being added together makes the whole Diſtances 135^{m}. and *x.* Lat. $112^{m}.3$. W. W. required.

Caſe 4. *Diſt.* 55^{m}. *and Dep.* 42.5^{m}. *Given: Required Courſe, and x. Lat.*

Right againſt Diſtance, 55. and over Title Dep^{r}. find 42.5. and you have againſt it 34.9. for the x^{s} Lat. and underneath at the Bottom,

you

you find 4 ½ Points, the Course, which if the Ship sail'd between the North and West, is N. W. ½ W.

Case 5. *Given Distances* 55^m. *and Difference of Latitude* 35^m. *Required Course and Departure.*

Right against Distance 55. and over Title Lat. (at the Bottom) find the *x*. Lat. 35. or nearest to it 34.9. Against which, on the left Hand, stands 42.5. or 42 ½ Miles the Departure, and at the Bottom 4 ½ Points: Which supposing the Ship sail'd South-Westerly, is S. W. ½ W. the Course steer'd.

Case 6. *Given* { *x*. Lat. 83,1^m, } req^d. { *Course.* / *Dist.* }

Find the corresponding Numbers 83,1. and 55,6. under Title *x*, Latitude and Departure (when the *x*. Lat. is greatest; but over Title Departure and Latitude, when the Departure is greatest) and at Top, (or the Bottom). You have the Course 3 Points, which if in the N. E. quarter the Ship sailed, is N. E. by N. And in either of the right or left Hand Columns, titled Dist^s. (or *x*. Long.) you have 100 Miles, the Distance sailed, W. W. R.

Note, In the three first Cases of Plain Sailing, if the Course be given in Degrees, make use of the Traverse Table in Degree; and proceed as before directed for Points of the Compass. Also in the three last Cases, if your Numbers, (as Distances and Departure, *&c.*) do not nearly agree together in the Traverse Table of Points, then seek them in the Traverse Table of Degrees, and proceed as there directed, and your Course will be found in Degrees: Observing always to reckon your Points or Degrees of the Course from the North and South Points, towards the East and West, according to the Quarter of the Compass the Ship hath sailed in.

Method

Method 3. *By Natural Arithmetick.*

And (the ſo called) given Numbers, which are nothing elſe but the Natural Sines, Tangents, *&c.* to every Point ½ and ¼ Point of the Compaſs, or Courſe ſteer'd; and may readily be collected from the aforeſaid Traverſe Tables. *Viz.*

By taking the *x.* Latitudes and Departures, anſwering to the Points and Quarters of the Compaſs, againſt the Diſtance 100 Miles, (I have ſhewn the Calculation of the Natural Sines, *&c.* in my *Engliſh Academy*, by an eaſy Method.) Now if theſe (given or) natural Numbers be committed to Memory, we may give a Solution to Plain Sailing, by common Arithmetick, without Books or Inſtruments. See the three firſt Columns of the Table, N°: 16. The 1. repreſents the Points and Quarters, the former in literal, and the latter in numerical Figures, in their natural Order, againſt which ſtands the natural Sines and natural Tangents to the ſaid Points, *&c.*—

Example.

What's the natural Sine and its Complement of a S. W. ½ W. Courſe being 4 Points 2 Quarters from the Meridian, and its Complement 3 Points 2 Quarters? I find IV. and ½ in the firſt Column, againſt which ſtands N. Sine 773. (and N. Tangent 1218.) and againſt III. and 1, 2, downwards, N. Sine 634. (N. Tang. 820.) the Complement of the Courſe; which indeed is obvious to any, without any Example. Proceed we now to

Caſe 1. *Given Courſe*, N. E. by N. *Diſt.* 107^{m}. *Requir'd x. Lat.* and *Departure.*

By the Rule of Three:

	P.		P.	
1. As R. VIII.	Diſt^{s}.	:: S. C. III.	Dep^{r}.	} Req^{d}.
N.S.	m	N.S.	m	

As 1000 .. 107 :: 555 .. 59. and $\frac{11}{1000}$

2 As

P. P.
As R. VIII. Dist. : : S. C. C. V. *x.* Lat. } Req.d
N.S. m N.S. m
— S. 1080 .. 107 : : 831 .. 88,1$\frac{2}{10}\frac{2}{0}$

Case 2. *Given, Course* N. W. ½ W. *x. Lat.* 70m
To find the Distances Run, and Departure.

As S. C. C. .. *x.* Lat. : : R .. *Distance,*
N.S. m. N.S. m
— 634 — 70 — 1000 — 110,260.

As S. C. C. .. *x.* Lat. : : S. C. .. Depart.
m m
— 634 — 70 : : 773 — 85,220.

Case 3. *Course,* S. E. *by* S. *Departure* 75m
Given. To find the Diff. and Dep.t Lat.

As S. C. .. Departure : : R .. Distance
— 555 — 75 — 1000 — 135 Miles.

As S. S. .. Dep.t : : S. C. C. .. *x.* Lat.
m
— 555 — 75 — 831 — 112,55 Miles.

Case 4. *Dist.* 135m. *and x. Lat.* 112.55m.
Given. Requir'd Course, and Departure.

As Dist. .. R : : *x.* Lat. .. S. C. C.
— 135m. .. 1000 — 112.5. .. ,833. the nearest to which in the Table (or by your Memory) is 831, against which ſtands 5 Points, whoſe Comp. 3 Points, is the Courſe, S. W. by S. if the Ship ſails South-weſterly.

As R .. Dist. : : S. C. Departure
— 1000 — 135 555 — 74,925 Miles.

Case 5.

Case 5. *Given Distances,* 135^m. *and Departure,* 74,9^m. *Requir'd Course, and x. Lat.*

As Distance .. R :: Departure .. S C.

—— 135 .. 1000 —— 74,9 —— 554+. the nearest N°. to which is 553, or 3 Points; or S. W. by S.

As R .. Dist. :: S. C. C. .. *x.* Lat.

—— 1000 —— 135 —— 831 —— 112,185 Miles.

Case 6. *Given x. Lat.* 112^m,2. *and Depart.* 75^m. *Requir'd Course and Distances.*

As *x.* Lat. .. R :: Depart. Tang. Course

—— 112,2 .. 1000 —— 75^m,669, the nearest N°. is N. Tang. 668; against which stands 3 Points; so the Course is S. W. by S. as before.

As S. C. Depart. :: R .. Dist.

—,555 — 75^m — 1000 — 135^m.

Method 4. Plain Sailing.

See the second Table annex'd to the Table for finding the Miles answering a Degree of Longitude in any Latitude. (N°. 128.)

Rule. As the tabular Distance is to the true Distance, so is the tabular Departure to the true Departure requir'd.

Again.

As the tabular Distance is to the true Distance, so is the Difference of Latitude upon all Rhumbs, (60 Miles) to the true *x.* Lat. requir'd.

The Table is thus calculated for every Point and Quarter-point of the Mar. Compass, the *x.* Latitude being 60 (or 1 Degree) by Case 2^d. of P. S. saying; As S. C. of any Point, or Quarter-point given, is to the *x.* Lat. 1° or 60^m. so is Radius 90° to the tabular Distance required.

Again

Again.

As S. C. of any Rhumb, or Point, is to the *x.* Lat. on all Rhumbs 60^m. ſo is the S. of the ſaid Rhumb, to the tabular Departure required.

Caſe 1. *Courſe* N. E. by N. } Dem^d. } *x.* Lat.
Diſt. 107^m. } } Depr.

As Tab. Diſt. .. true Diſt. :: Tab. Departure, .. true Departure.

—— $72,2^m$ —— 107^m —— $40,1$ —— $59,3^m$.

As Tab. Diſt. .. true Diſt. :: *x.* Lat. on all R^s. .. true *x.* Lat.

—— $72,2^m$ —— 107^m —— 60^m —— $88,9^m$.

Caſe 2. *Courſe* N. W. , W. } Req^d. } *Diſt.*
x. Lat. 70^m. } } *Depart.*

As *x.* Lat. Given :: Tab. Diſt. Tr. Diſt.

—— 60^m —— 70^m —— $94,6^m$ —— $110,3^m$.

As *x.* Lat. .. *x.* Lat. given :: Ta. Dep. Tr. Dep.

—— 60^m —— 70^m —— $73,2^m$ —— $85,3^m$.

Caſe 3. *Courſe* S. E. *by* S. } Dem^d. } *Diſtance.*
Departure 75^m. } } *x. Latit.*

As Ta. Dep. .. Tr. Dep. :: Tab. Diſt. .. Tr. Diſt.

—— $40,1$ —— 75^m —— $72,2$ —— 135^m.

As Ta. Dep. .. Tr. Dep^r. :: Ta. *x.* Lat. Tr. *x.* Lat.

—— 40.1 —— 75^m —— 60 —— 122^m.

Caſe 4th. 5th. and 6th. are ſolved by the 47th. of the 1st of *Euclid*'s Elements, and the Number 86, to find the *Courſe* thus;

Caſe 4

Case 4. { *Dist. between* S. and W. 135^m. *and x. Lat.* 112^m. *given; to find the Departure and Course.*

Rule, The Square Root of the Difference of the Squares of the Distance, and *x*'s Latitude is equal to the Departure.

Solut. $135 \times 135 = 18225$ the Square of the Distance.
And $112 \times 112 = 12544$, the Square of the *x*. Lat.
Then $18225 - 12544 = 5681$, the *x*. Whose

$\sqrt{5681} (= {}^{m}75$. the Departure required.

Now to find the Course in this, and the 5th. and 6th. Case, observe this Rule.

As the Sum of the Dist. more $\frac{1}{2}$ the greater Side, be it either the *x*. Latitude, or Departure, is to the lesser Side, either *x*. Lat. or Departure. So is 86 (always) to the Angle of the Course required.

Operation.

Dist. $+ \frac{1}{2}$ *x*. Lat. *i. e.* $135 + 56 = 191$ Z.
As Z 191 .. 75 :: 86 .. 33° : 46′ ∠ of the Course, that is, S. W. by S.

Note. To bring out the odd Minutes, multiply the Remainder of the Division by 60 (the Minutes in a Degree) and divide the Product by the same Divisor, it exhibits the Minutes. Or annex two Cyphers to the said Remainder, and divide as before, the Quote multiply by 60, cutting off two Figures from the Right-hand, the Residue shews the Minutes, as before.

1. Observe the same Rule and Method for finding the Course in the two following Cases.

2. If the *x*. Lat be greater than the Departure (as in the last Case) the Operation finds the Sine of the Course: But if the Departure be greater than the *x* Lat. it finds the Complement of the Course, which subtracted from 90, gives the Angle of the Course.

Note, If the Learner cannot extract the Square Root, (I refer him to my *Engliſh Academy*, the firſt Part. However) I have made a Table of Squares, See (Number 5.) for his Eaſe, whereby may be found the Squares, or Square Roots of any Number (not exceeding 330. which is ſufficient) by Inſpection. As for Inſtance: What's the Square of 135? Look under N. 135 againſt which on the Right-hand, ſtands 18225 its Square required.

2. I would know the Square Root of 5625? Look under Title *Squ.* for the Number given 5625 (or neareſt to it) againſt which, on the Left-hand, ſtands 75 the Square Root ſought.

Caſe 12. { *Diſtance* S. W^ly. 135 *m. Dep.* 75. *x.* *given*; *required Courſe, and x. Lat.*

Rule. The Square Root of the Difference and Departure is equal to the Difference of Latitude required.

Operation.

$135 \times 135 = 18225$, ſquare Diſtance.
$75 \times 75 = 5625$, ſquare Departure.
m.
There $\sqrt{2}$) 12600 (= 112. *x.* Lat.
.....

As Z *Diſt.* $+\frac{1}{2}$ X Lat. .. Depart. :: given N. ∠ *Cour.*
m
191 — 75 — 86 — 33° : 46.
i. e. Courſe S. W. by S.

Caſe 6. { *x. Lat.* 112^m. *Departure*, 75 W. *Given*; *Courſe and Diſtance required.*

Rule. The Square Root of the Sum of the Squares, of the Difference of Latitude, and Departure,

parture, is the Diſtance ſought. *Operation.*

112 × 112 = 12544 ſquare × Lat.
75 × 75 = 5625 ſquare Departure.
There Z. $\sqrt{}^2$ 18169 (= 134,8^m. Diſt. or near 135 Miles. . . .

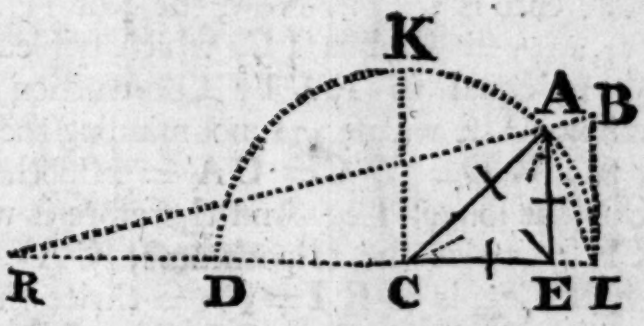
As Z Diſt. ½ × Lat. .. Dep^r. :: G.^{n}. N°. ∠ Courſe.
—— 191 —— 75 —— 16 .. 33°. : 46′.
The Courſe is S. W. by S. W. W. R.

I ſhall now ſhew how the given Number 86 was found out by *Snellius*, (altho' omitted by all our Authors of *Navigation*, who have uſed it in Operation).

Theorem.

As the Sum of the Hipothenuſe, and ½ the greater Leg, (be it Baſe or Perpendicular) is to the leſſer Leg.

So is 86, a conſtant Number, to the Angle oppoſite to the ſaid leſſer Leg, (be it either Baſe or Perpendicular.)



Conſtruction.

In the Scheme above, let the right-angled Triangle propos'd be C E A, then with the Radius C A (= Hipothenuſe) deſcribe the Semi-circle I K D, and producing the Diameter towards R, make D R = Radius, C A or C D; draw alſo the Tangent Line I B, and the Line R A produced to meet the Tangent I B in B; then ſhall the Tan-

gent I B be equal (or ſufficiently near) to the length of the Chord Line I A, which is equal to the Angle A C E required; and R I is the Triple of the Radius C I or Hipothenuſe A. C.

Demonſtration.

Let the Tangent Line I B be equal to the Chord Line I A; A E being parallel to I B, the Triangles R I B, and R E A are ſimilar, by reaſon of the parallel Line A E to I B; therefore proportional by the 6th of the 4th of *Euclid*: And 'twill be

As R E .. E A :: R I .. I B. And
As R E .·. E A :: R I .. I A (= I B.)

the Chord of the Angle A C E, which muſt be accounted an Arch of a Circle, whoſe Circumference is = 360°, its ½ = D I. Now let the proportion of the Diameter of a Circle to its Circumference be as 7 to 22; Or as 113 to 355.— Then; As 113 .. 355 :: 360 .. 114,5915, the Diameter D I, in ſuch Parts whereof the whole Circumference is 360°: Now, the ½ of 114,5915, is = 57,2957 = Radius I C, which tripled is = 171,8871; equal to R I by Conſtruction; but for common Uſe we uſe 172, not minding the Fraction; and R D = D C = C A = Hipothenuſe; and C is the longeſt Leg. And therefore it will be, As R E = twice the Hipothenuſe, C A + C E, the longer Leg, is to R I = 172 = thrice the Radius. So is E A the ſhorteſt Leg. to I B = I A = Angle A C E required. Or more briefly, by taking ½ the two firſt Terms, it will be,

As the Hipo. C A + ½ C E, the longer Leg.
Is to ½ R I 172 = 86; (or more exactly ½ R I 171,8871 = 85,94355)
So is the ſhorteſt Leg E A, to its oppoſite Angle A C E required. Q. E D.

The

The Application of which to *Plain Sailing* is obvious, because the Hipo. represents the Dist. and the two Legs the *x*. Lat. and Departure.

Plain Sailing. Meth. 5.

The Solution of Plain Sailing *by Natural Arithmetick, by the Pen only.*

First, You must find whether the Difference of Latitude or Departure be the longest Side in the Triangle, and that is easily known thus; 1. If the Course be less than four Points from the North or South, the *x*. Latitude is greater than the Departure. 2. If the Course be more than four Points from the North or South, the *x* Lat. is less than the Departure. 3. If the Course be just four Points, the *x*. Lat. and Departure are both equal: Then, if the *x*. Lat. be the lesser Side, it must be assumed 1,0000. If the Departure be less, it must contain 1,0000. Then the Rule is,

1. Always divide 172 (the double of 86, before found) with a competent Number of Cyphers annexed, by the Degrees and decimal Parts of a Degree contained in the Angle opposite to the lesser Side.

2. From the Square of this Quotient, you must always subtract 3, and out of the Remainder extract the Square Root.

3. Subtract this Square Root from the double of the Quote, $\frac{1}{3}$ of this Remainder shall be the Distance assumed.

4. Subtract the Double of the assum'd Distance from the said Quote, the Remainder shall be the assumed Difference of Latitude, or Departure, according to the Scale, whereby the lesser Side contained 1,0000.

And thus you'll have a Triangle whose Sides shall be similar and proportional to the Sides of

the *Plain Sailing* Queſtion propoſed; which Sides requir'd may be found by the *Rule of Three.*

Laſtly, in this Method you muſt reduce all the ſexagenary Minutes in a Degree into Decimals, by this Proportion.

As 60′ .. 10000 :: 15 .. ,2500, the Decimal of 15 Minutes; and ſo by the reſt. And by this Proportion was the Table of Decimals of Minutes calculated, which ſhews the Decimals contained in any Number of Minutes; and contrary by Inſpection.

C. 1. *Given Courſe* N. E. by N. *Diſtance* 107ᵐ. *Requir'd x. Lat. and Departure.*

By the firſt *Obſervation*, the Courſe being leſs than four Points, the *x.* Lat. is greater than the Departure; therefore the Departure muſt be aſſumed 1,000. And the Angle given is,

33° : 45″. Or in Decimals 33°,75.

Operation.

33,75) 172,00000 (5,096 Quote.

2

Double Quote = 10.192

5,096 × 5,096 = 25,969216 Quote ſquar'd; leſs 3 is = 22,969216, $\sqrt{2}$) 22,969216 (= 4,792 Sq. Root.

Then from the double Quote 10.192, ſubtract the Square Root —— —— 4,792

Remains —— 5,400

⅓ of the Remainder is the aſſ. Diſt. 1,800

The Diſt. doubled is —— — 3,600

Which ſubtracted from the Quote, 5.096

The Remainder is the aſſum'd *x.* Lat. = 1,496

Then

Then by the *Rule of Three.*

As ſuppoſed Diſt..true Diſt. : : ſup. Dep. true Dep.
——1,8——107m.——1,5000——59,+m
As ſup. Diſt..true Diſt. : : ſup. *x.* Lat. true *x.* Lat.
—— 1,8——107m——— 1,5 ———89m.+.

Caſe 2. *Courſe* N. W. ½. W. *x. Lat.* 70m. *given*; *Diſtance and Departure required.*

The Angle of the Couſe is 39° : 22; or in Decimals, 39,3667. Here the *x.* Lat. is the leſſer Side, and muſt be 1,000.

39,3667) 172,000000 (4,39 Quote.

2

Double Quote 8,78

Quote ſquar'd leſs, 3 is ——— 16,2721
Whoſe Square Root is ——————— 4,03
Subtract from Double Quote——— 8,78

Remainder is =4,75

⅓ of the Remainder is the Diſt. =1,583

The Diſt. doubled is =.. 3,166
Which ſubtract from Quote ——— 4,39

Remainder is the aſſumed Depart. 1.224

Then by Proportion ſay,

As ſup. *x.* Lat. true *x.* Lat. : : ſup. Diſt. true Diſt.
—— 1,000 —— 70 —— 1,583 ——111,9m
As ſup. *x.* Lat. .. true *x.* Lat. : : ſup. Dep. true Dep.
—— 1,000 —— 70 —— 1,224 —— 85,6m

Case 3. *Course* S. E. *by* S. *Depart.* 75^{m}. *given to find Dist. and Diff. of Lat.*

The Angle of the Course is 33,75 as in the first Case. Consequently the Departure is the lesser Side, and must contain 1,000.

Therefore by the first Case, $\frac{1}{3}\frac{7}{3}\frac{2}{3}\frac{2}{3}\frac{8}{5}$
s = 5,096: Which doubled is 10,192

and the Square thereof 25,969216; made less by 3, is = 22,969216; whose Square Root is 4,792 as before.

Then from Quote doubled ——	10,192
Subtract the Square Root ——	4,792
Remains	5,400
$\frac{1}{3}$ of the Remainder is the Dist,	1,800
The Distance doubled is,	3,600
Which subtracted from Quote	5,096
The Remainder is the assumed *x*. Lat	1.496

Then say

As sup. Dep. .. true Dep. :: Sup. Dist. true Dist.
—— 1,000 —— 75 —— 1,8 —— 135^{m}.
As sup. Dep. .. tr. Dep : : sup. *x*. Lat. tr. *x*. Lat.
—— 1,000 —— 75 —— 1,496 —— 112,2^{m}.

The 4th, 5th, and 6th Cases are wrought by the Square Root, and Number 86; as in Method the 4th foregoing, which to avoid Prolixity I omit, and proceed to

Method 6th. Plain Sailing.

In this Method, (which is the same as in *Wilson's Navigation* new Model'd, Page 161.) there must first be a Number found, called the Natural

ral Radius, which may produce the ſame Anſwer in Natural Arithmetick, that the Radius, or Sine of 90°. produces in a Sinical Proportion, or by Logarithmetic Sines: And this Natural Radius the aforeſaid Author directs us thus to find by this

Axiom.

Take the Angle whoſe oppoſite ſide is either given or ſought, and divide four times the Square of its Complement to 90°., by 300. added to 3 times the ſaid Complement, and then the Quotient added to the ſaid Angle is the Natural Radius required.

And this Rule is univerſally true in all Angles, from 0, to 90°.

But becauſe in Angles under 45°, the Complements are above 45°; and the Squares amount to greater Numbers than the Squares of the Complements of the Angles above 45°. Therefore, to render the Work yet more eaſy, in finding the Natural Radius for all Angles under 45°. the Rule, or *Axiom* 2. is, Divide 3 times the Square of the Angle (whoſe oppoſite Side is given or ſought) by 1000, the Quotient added to 57,3, the Sum is the Natural Radius requir'd.

Then *Rule* 1. is, An Angle and Side given, to find another Side.

Say, As Natural Radius is to the Diſtance; So is the Angle (of the Courſe or its Complement) by which the Natural Radius was found, to its oppoſite Side (the Departure, or *x*, Lat.)

Thus, when the Courſe and Diſt. is given. But if the Courſe and *x*. Lat. or Courſe and Departure be given; As the Angle (of the Courſe, or Comp) to its oppoſite Side (the Departure, or *x*. Lat.) So is Natural Radius, to the Diſtance requir'd.

Note, 57,3 is the Semi-diameter, or Radius of a Circle whoſe Circumference is 360.

Caſe 1.

Case 1. *Given Course* N. E. *by* N. *Dist.* 107 *Miles; required the x. Latitude and Departure?*

Note. 'Tis best to find the lesser Side required first, because the Natural Radius is more easily found by *Axiom* 2.

The Course is the lesser Angle 33.75, whose Square *viz.* 33,75 × 33,75 is = 1139,0625.

Multiplied by 3

1000)3,4170(,1875

57.3 Added

60,717 is the Natural Radius, or more brief 60,7, which is exact enough: Then say,

As Nat. Rad. .. Dist. :: S. C. .. Departure.

——60,7——107m.——33,75——594,m. req^d.

Then find the *x.* Latitude by Case the 5th, Meth. 4. Thus,

The Distance squared is——11449,

Departure squar'd is——3481.

Their Difference is——7968 Miles,

Whose square Root=89^m. the *x.* Latitude required.

Case 2. *Course* N. W ½ W. *x. Latitude* 70m. *given, to find the Distance and Departure?*

Here the Side given is also opposite to the lesser Angle; therefore by *Ax.* 2. Co. Course is 39°,36+

The Square of 39,36 is 1549,2

Multiply by 3

Divide by 1000)4,6(47,6

To which Add 57,3

The Natural Radius=61,9 or 62

As

As S. C. C. .. *x.* Lat. :: Nat. Rad. .. Dist^{s}.
—39,36 —— 70m. —— 62 —— 110,2m.

Then for the Departure by the ſquare Root, and by *Method* 4. *Caſe* 4. The Square of the Diſtance is 1211,44, and the Square of the *x.* Latitude is 4900, their Difference is 7244, whoſe ſquare Root is 85 Miles the Departure required.

Caſe 3. *Courſe* S. E. *by* S. *Departure* 75 *Miles given; required Diſtance and x. Lat.*

Here the Departure is the ſhorteſt Side, and the Angle of the Courſe is 33,75, therefore, the natural Radius is the ſame as in the firſt Caſe, of this Method, *viz.* 60,7. Then the Proportion is;

As S. C. .. Dep^{r}. :: Nat. Rad. .. Dist^{s}.
—33,75° —— 75m. —— 60,7 —— 135m.

Then by the ſquare Root find the *x.* Latitude as in the firſt Caſe of this Method.

The Diſtance ſquar'd is —— 18225
The Departure ſquar'd is —— 5625

Their Difference is —— 12600

$\sqrt[2]{}$)12600(=112 Miles the Difference of Latitude required.

Sometimes the Angle of the Courſe is given in Degrees, often in Uſe in our Ships of War, therefore I ſhall give one Example more to the firſt Caſe, and work it by the firſt *Axiom*, *Ex.* Courſe N°. 56°. E^{r}. Dist^{s}. 90m. given; Difference, Latitude and Departure required.

Here

Here the Departure required is oppoſite to the bigger Angle;

Therefore by *Axiom* 1. 90°56°=34° Comp.
34° ſquar'd is = 1156
Multiply by 4
Dividend 4624
34° × 3 + 300 = 402 Diviſor
And 402)4624(=11,5
To which add 56 the bigger∠
Sum is the Natural Radius 67.5 Then ſay,

As Nat.Rad.. Diſt. :: S. C. .. Depr.
——67,5—— 90m.——50°.——74,6m. +

The *x*. Latitude is found as before in *Caſe* 1. of this Method, which is 50 Miles.

Method 7. Plain Sailing.

By the Sinical Quadrant, at the latter End of this Treatiſe.

This *Geometrical* and *Trigonometrical* Inſtrument, exhibits the various Triangles (or Caſes) in *Plain Sailing*, *Traverſe* and *Mercator's Sailing*, (projected and meaſured to your Hand at the firſt viewing of it) and is very exact and eaſy in Operation.

Conſtruction. It is compoſed of concentrick Arches, (or rather quarters of Circles) and of three Sorts of right Lines, *viz.*

1. Thoſe drawn parallel to the Line A P, repreſent the Sines and Meridians, and are parallel to the North and South, upon which we count the Miles or Leagues of *x*. Lat.

2. Thoſe drawn parallel to the Line A C repreſent the Sines, Complements and Parallels, and

are

are Parallels to the East and West, upon which we count the Miles or Leagues of Departure from the Meridian. And;

3. Those drawn from the Center of the Quadrant A, to the Limb, represent the Rhumbs or Points of your Compass, or several Courses steer'd, and it is upon them that we count the Distance, or Miles, or Leagues sailed, which Miles or Leagues are distinguished or marked by the several Arches or Quarters of Circles.

Lastly, You must have a Silk Thread through the Center A, fastened by a Knot underneath, and then is this Quadrant fit for Use, which we come now to shew.

Case 1. *Course* S. W. *by* S. *Distance* 45 *Leagues given to find the x. Latitude and Departure.*

Count 45 l. upon the third Rhumb (or Point from the North) to wit, upon the Arches, and from that Point (where you are to prick a Pin) follow that Line to the Meridian A P, and you will have on the said Meridian 37l. for the *x.* Latitude, and running down your Eye perpendicular to the Parallel A C. you have 25 Leagues for the Departure which was requir'd.

Case 2. *Course* S. W. *by* S. *x. Lat.* 36 *Leagues; required Distance and Departure?*

Practice. Count upon the Meridian A P 36, and observe where it cuts the third Rhumb (pricking down your Pin there) the Arch intersecting this Point, trac'd (or followed) to the Meridian A P gives 43 Leagues for the Distance; and again, tracing down the Meridian Line from the said Pin or Point, to the Parallel A C. you have nearly 24 Leagues for the Departure required.

Case 3.

Caſe 3. *Courſe* N. E. *by* N. *Departure* 26 *Leagues given; to find the Diſtance and x. Latitude?*

Practice. Count on the Parallel A C. 26. and tracing up that Meridian Line, till it cut the third Rhumb-line, pricking your Pin down there, trace the interſected Arch to the Meridian A P, or Parallel A C, and it gives 47 Leagues the Diſtance required, and tracing along the parallel Line, that interſects the Point or Pin, to the Meridian A B, you will find 39 Leagues the *x.* Latitude required.

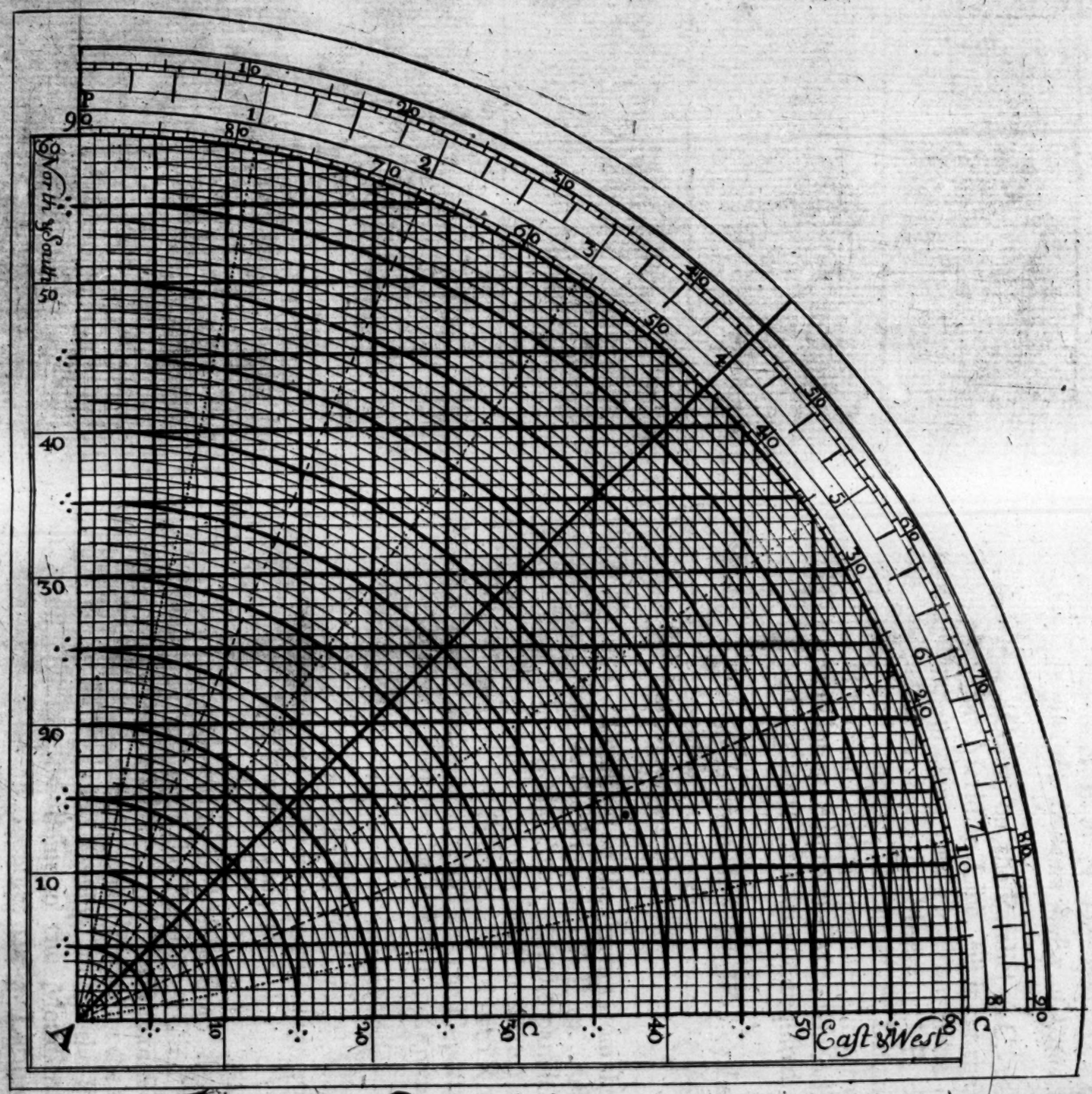
Caſe 4. *Diſtance between the South Weſt* 55 *Leagues, and x. Latitude* 39 *Leagues given, to find the Courſe and Departure?*

Practice. Counting on the Arches from the Center A 55, and on the Meridian A P. 39. Obſerve the Interſection of the Arch with the parallel Line from A P, (pricking down the Pin there,) which Point of Interſection falls upon the fourth Rhumb; therefore the Courſe is S. W. and the Departure by Conſequence equal to the *x.* Latitude given, *viz.* 39 Leagues.

aſe 5. *Diſtance between the North and Eaſt* 29 *Leagues, and Departure* 24 *Leagues given; to find the Courſe and x. Latitude?*

Practice. Counting as before from A on the Arches 29, and upon the Parallel A C 24. Trace up the Meridian Line, and 'twill interſect the Arch 29, on the fifth Rhumb; therefore the Courſe is N. E. by E. And running along the Parallel from the foreſaid Point to the Meridian A P, 'twill cut it in 16 Leagues the *x.* Latitude required.

Caſe 6.



The Sinical Quadrant

p 77

Caſe 6. *Diff. Lat.* 39 *Leagues, and Departure* 16 *Leagues, (between the* S. *and* W.) *demand Courſe and Diſtance ?*

Practice. Count upon the Meridian A P 39, and on the Parallel A C 16, obſerving where the Parallel, and Meridian from thoſe Points interſect each other, (pricking down your Pin in that Point) which you will find in the ſecond Rhumb Line, ſo that the Courſe is S. S. W, and alſo tracing the Arch interſecting the foreſaid Point to the Meridian Line A P or Parallel AC, and it gives 42 Leagues for the Diſtance required.

Thus have I gone through all the various modern Methods of *Plain Sailing*, viz.

1. By the *Plain Chart.*
2. *Geometrical.*
3. *Logarithmetical.*
4. *Inſtrumental*, by *Gunter*'s Scale.
5. By the *Traverſe Tables.*
6. By natural *Arithmetick*, by given Numbers, or natural Sines of Rhumbs and Quarters.
7. By another Table of given Numbers, and the ſquare Root and Number 86, *Arithmetically.*
8. By *Natural Arithmetick*, and a ſimilar Triangle, whoſe leſſer Leg muſt be aſſumed 1,000.
9. By finding a Radius to work by natural Numbers.
10. By the Sinical Quadrant.

I paſs on now to *Plain Sailing Traverſe.*

CHAP.

CHAP. III.

Plain Sailing Traverſe.

1. *Definition.*

A Compound Courſe or Traverſe is, when a Ship, upon the ſhifting of Wind, or other Accidents or Occaſions, ſails upon ſeveral Courſes in 24 Hours.

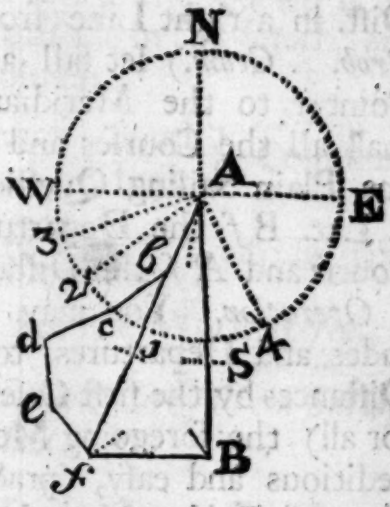
Reducing or reſolving a Traverſe (after Leeway and Variation hath been allow'd for, as ſhall be ſhew'd when we come to treat of Working a Days Log, and keeping a Sea Journal) is to reduce the ſeveral Courſes by the Compaſs, and Diſtance found by the Log, into one Courſe and Diſtance.

Example 1. *Yeſterday at eight in the Evening, the* Lizard-Point *bore off us* N. W. *by* N. *Diſtance about 6 Leagues, and we have ſailed till this Day at Noon as by the Log-Board,* viz. *the Starboard Tack aboard, the Winds from* W. *to* W. N. W. N. W. W. S. W. *and* S. W. *Courſes ſteered are* S. S. W. 15^{m}. S. W 12^{m}. W. S. W. 14^{m}. S. 9^{m}. S. S. E. $12.^{m}$. *I demand the x. Latitude and Departure, the Latitude in and the direct Courſe and Diſtance from the* Lizard?

Conſtruction.

1 (By *Prob.* 2. of *Geometrical Prob.*) with a Chord of 60°. deſcribe a Circle and quarter it with the two Diameters N. S. (produc'd) and W. E. for the North, South, Eaſt and Weſt Points. 2. By

2. By Help of Line of Rhumbs ſet off from the South Point S, the given Courſe, *viz.* S.S.W. 2 Rhumbs from S to 1. and draw the Rhumb Line A 1.



3. S.W.=4 Rhumbs, Set from S. to 2. and draw the Rhumb Line A 2.

4. W.S.W.=6 Rhumbs, ſet from S. to 3, and draw the W. S. W. Rhumb Line A 3.

5. Set off S. S. E. = 2 Rhumbs from S. to 4. (to the Eaſtward) and draw the S. S. E. Rhumb Line A 4. (and when any of the Courſes in the Traverſe are North-Eaſterly, or North-Weſterly, ſet off the Rhumbs or Points from N. toward E, or from N. towards W. and draw the Rhumb Lines as before.)

6. From a Scale of equal Parts ſet off the firſt Diſtance ſailed from A to *b*, on the S. S. W. Rhumb Line.

7. From the Point *b*, (by *Prob.* 6. *Geom.*) draw a Line parallel to the S. W. Rhumb Line, and ſet off the ſecond Diſt^{s}. 12=Parts from *b* to *c*.

8. From the Point *c*, draw a Line parallel to the W. S. W. Rhumb, and ſet off the third Diſt^{s} 14= Parts from *c*, to *d*.

9. From *d*, draw a Line parallel to the South, and ſet off the fourth Diſt^{s}. 9^{m}.=Parts from *d*, to to *e*.

10. From *e* draw a Line parallel to the S. S. E. Rhumb, and ſet off the fifth Diſt^{s}. 12= Parts from *e* to *f*; ſo ſhall *f* be the Place of the Ship at the End of her Traverſe.

Laſtly, Draw from *f.* to A the Ships true Diſt. in a right Line from the *Lizard*; and (by *Prob.* 3. *Geom.*) let fall a perpendicular from the Point *f* to the Meridian produced; as *f* B, ſo ſhall all the Courſes and Diſtances be reduced to one Plain Sailing Queſtion, A B *f*. A B is the *x.* Lat. B *f* the Departure, the Angle at A the Courſe and A *f* the Diſtance.

Operation. You may find the ſeveral *x* Latitudes and Departures, to the ſeveral Courſes and Diſtances by the firſt Caſe of *Plain Sailing*, by any (or all) the foregoing Methods; but the moſt expeditious and eaſy, (practiſed at Sea) is by the *Traverſe Table*, *Method* 2. *Plain Sailing*. Thus; as in the firſt Caſe thereof, making a Table of ſeven Columns as here under, then collecting the ſeveral *x.* Latitudes and Departures to each Courſe and Diſtance, place them in the *Traverſe Table*, obſerving this Rule here under the Table.

Courſe	D.	P.	N°.	S°.	E^{t}.	W^{t}.
S. S. W.	15	2		13.8		5.7
S. W.	12	4		8.5		8.5
W. S. W.	14	6		5.3		12.9
S°.	9	0		9.0		
S. S. E.	12	2		11.1	4.6	
		x. Lat. S°.		47.7	4.6	27.1 W.
					Sub.	4.6 E.
					Departure	22.5 W.

Lat. Lizard 49°.56′. N.
x. Lat. 00:48 S^{ly}. Sub.

Lat. come into 49:08 N.

Rule. When the Courſe is N°. Eaſterly, place the *x.* Latitude in the North Column, and Departure in

in the Eaſt Column; but when the Courſe is S°. Weſterly, place the *x*. Latitude in the South, and Departure in the Weſt Column.

Then adding up { North / Weſt } Column and { South / Eaſt } Columns,

Their Difference is the { Diff^s. Lat. / Departure } of the ſame Name with the greater. See the Work above.

For the Courſe and Diſtance by Caſe 6. *Plain Sailing, Method* 1.

As *x*. Lat. .. R : : Dep^r. Tang. Courſe
——48m.——90°.———23m. S°. 25°. 29'. Weſt.
As S. C. .. Dep^r. : : R. .. Diſt^s.
—S. 25°. 29'.—— 23——S. 90°.—— 53 Miles.

Or more Expeditious by G. S.

The Ext. reaches { from { *x*. Lat. 48m. to Dep^r. 23m. / T. 45°. to T. C. 25°. 29'. } on { N^rs. / T^ngs. }

The Ext. reaches { from { S. C. 25°. 19'. to R S. 90°. / Dep^r. 23m. to Diſt^s. 53m. } on { Sines / N^rs. }

Example 2. *Yeſterday Noon we were in the Latitude of* 49°. 08'. N. *and till this Day Noon we have ſailed as by the Log-Board, with our Star-board Tacks aboard,* viz. S. *by* W. 19m. S. W. *by* S. 10m.. S. W. *by* W. 6. W. S. W. ½ W. 8m. W. *by* N. 7m. N. W. 2m. *Star-board Tack aboard.* S°. 5m. S. S. W. 6m. S. W. 2m. W. S. W. 3. *ſmooth Water and a ſmall Gale; Winds, at* S. E. *by* E. S. E. *by* S. S. *by* E. S. ½ W. S. W *by* S. W. S. W. Weſt. W. N. W. N. W. *I demand the x. Latitude and Departure, direct Courſe and Diſtance made good, with the Latitude the Ship is in?*

Traverſe Table.

Courſe	D	P.	*x.* Lat. N.	*x.* Lat. S.	Dep. E.	Dep. W.
S. b. W.	19	1		18.6		3·7
S. W. b. S.	10	3		8.3		5·6
S.W.b.W.	6	5		3·3		5·0
W.S.W½W.	8	6½	1·4	3.8		7·1
W. b. N.	7	7	1·4			6.9
N. W	2	4				1·4
S°.	5	0		5.0		
S. S. W.	6	2		5·5		2·3
S. W.	2	4		1·4		1·4
W. S. W.	3	6		1.1		2.8
			2. 8	47.0	Dep.	36.2 W.
				2.8		

x. Latitude 44.2 Sou^ly.

Latitude from 49 : 08 N.
x. Latitude 00 : 44 S.

Latitude in 48 : 24 N.

Having finiſhed your Traverſe as directed in the laſt Example, you may readily find the Courſe and Diſtance by *Gunter*'s Scale, as there is ſhewn, *viz.*

The Ext. reaches } from { *x.* Lat. 44m. to Dep^r. 36m. / T. 45°. to T.C.S. 39°. 10 W. } on { N^rs. / T^ts.

The Ext. reaches } from { S.C. 39°. 10′. to R. S. 90° / Dep^r. 36. to Diſt. 57m. } on { Sines. / N^rs.

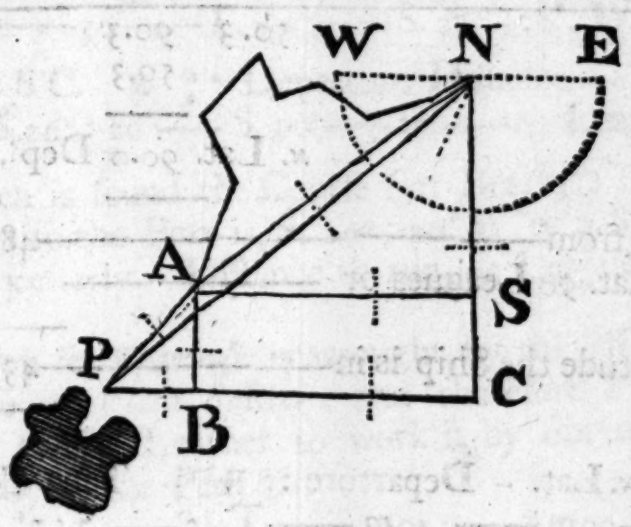
Note.

Note. If the Tenth Parts of the *x.* Latitude and Departure be leſs than 5, we throw them away; if more than 5, make the Miles one more.

I ſhall give a Solution to one more Traverſe, and that the moſt general and uſeful as may be; which being well underſtood, will be ſufficient for the Learner's Purpoſe.

Being Yeſterday Noon in Latitude of 48°. 24'. N. *and am bound to a Port in the Latitude* 40°. 54'. N. *which is* 510 *Miles to the Weſtward of my Ship but finding the Wind variable, I plie to Windward upon theſe ſeveral Courſes,* viz. S. W. *by* W. 25 *Leagues,* W. *by* S. ½ W. 30 *Leagues,* N. W. *by* W. 20 *Leagues,* Weſt 35 *Leagues,* N. *by* W. 40 *Leagues,* S. W. *by* S. 50 *Leagues,* S. S. E. 25 *Leagues,* S. *by* W. 60 *Leagues. I demand the x. Latitude and Departure, Courſe and Diſtance and Latitude the Ship is in, with the Courſe and Diſtance from the Ship to her Port at firſt Setting out, and at the End of her Sailing by the above-ſaid Courſes?*

1. From Lat. Depart. ——— 48°. 24.
Subt. the Lat. of the Port ——— 40 : 54



Remains *x.* Lat. —— 7°. 30'.
or 150 Leagues. ——
Departure 510m. is = 170 Leagues. Then by Case sixth of *Plain Sailing.*

As *x.* Lat. .. Dep^r. : : R. .. Tang. Course
—— 150^l. —— 170^l. —— T. 45°. —— S. 48°. 30'. W.

As S. C. .. R. : : Dep^r. .. Dist^s.
—— S. 48°. 30' —— S. 90°. —— 170^l. —— 226 Lgs.

So that the Course from the Ship to the Port at first Setting out, is S. 48°. 30'. W. or near S. W. ½ W. Distance 226 Leagues. 2. Then work your Traverse

		x. Lat.		Dep^r.	
Courses	D.	P.	N.	S.	E.	W.
S. W. b. W.	25	5		13.9		20.7
W. b. S. ½ W.	30	7½		2.9		29.8
N. W. b. W.	20	5	11.1			16.6
West.	35	8				35.0
N. b. W.	40	1				7.6
S. W. b. S.	50	3	39.2	41.9		27.8
S. S. E.	25	2		23.1	9.6	
S. b. W.	60	1		58.8		11.7
			50.3	90.3		149.2
				50.3		9.6
			x. Lat.	90.0	Dep^r.	139.6

Lat. from —— 48°.24 N.
x. Lat. 90 Leagues or —— 4:30 S.

Latitude the Ship is in —— 43:54 N.

As *x.* Lat. .. Departure : : R. .. Tang. Course
—— 90m. —— 140m. —— T. 45 —— S. 57°. 30'. W.

As

As S.C. .. R : : Dep^{r}. .. Diſts.
—S. 57°. 30′.—S. 90 m.——140 m——165 Lea.

So that the Ship's Courſe made good is S°. 57°. 30′. W. her Diſtance run 165 Leagues, and She is arrived into the Latitude of 43°. 54′. N°.

3. To find the Courſe (Bearing) and Diſtance from the Ship to her intended Port; its plain that the Port is to the South-weſtward of the Ship, becauſe ſhe hath not run her Southing 150 Leagues, and Weſting 170 Leagues down; therefore

From *x.* Latitude —— 150 Leagues
Take *x.* Latitude made — — — 90 Leagues

Remains *x.* Latitude to the Port — 60 Leagues

From Departure —— 170 Leagues
Take Departure made — — — 140 Leagues

Remains the Departure to the Port 30 Leagues

Therefore by Caſe 6. of *Plain Sailing*:
As *x.* Lat. .. Dep^{r}. :: R . . Tangent Courſe
——60——30——T. 45°——S. 26°. 20′. Weſt.

As S C. R : : Departure Diſtance.
— S 26° : 20′— S. 90 — 30 —62 Leagues

By which is found the Courſe (or Bearing) from the Ship to the Port is, S. 26° : 20′ W. or S. S. W. 3° : 5′ Weſterly. Diſtance to run, 62 Leagues.

Thus you ſee *Traverſe* is wrought by the 1ſt and 6th Caſe of *Plain Sailing*; and therefore I ſhall leave it to the Learner to work it by our other Methods, by the Pen, *&c.*

And proceed to Plain Sailing rectified by the Globe, call'd *Mercator*'s *Sailing*; altho' indeed it was the Invention of Mr. *Wright*; but *Mercator* ſtole the Invention from the Author, and publiſh'd it in his own Name.

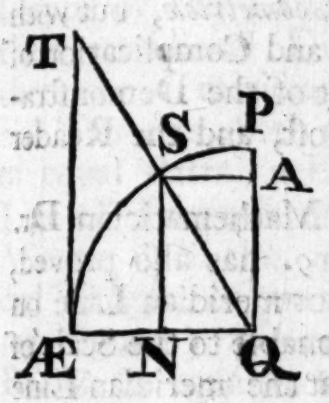
---

2. *Of Wright's Chart.*

THIS Chart ſhews, in any aſſigned Courſe, the Ship's Motion on any imaginary Plain, and the Meridians are parallel to one another, as in the Plain Chart, and divide the Equator into equal Parts, or Degrees, cutting it and the Parallels of Latitude at Right-Angles, but the Diviſions of the Meridians (by the Circles or Parallels of Latitude) are not equal, as in the plain Chart, but unequal, and do continually increaſe from the Equator towards both Poles, that is, the Parts of the Meridian at every Point of Latitude muſt increaſe as the Secants of theſe Latitudes; ſo that the Points of Latitude at each Parallel muſt be protracted in like proportion with thoſe of Longitude; and therefore the ſaid Author makes his Chart by this Proportion; as the Radius of the Parallel (or Sine Comp. of Lat.) is to the Radius of the Equator; ſo is a Degree of the Equator, to a Degree of Latitude ſo protracted: As to be repreſented in the Chart at ſuch a Diſtance from the Equator; that is, always in ſuch Proportion as is that of the Secant of the Lat. to the Radius. See the following Scheme.

Con-

Conſtruction.



Let Æ P. B be $\frac{1}{4}$ of the Miridian of the Globe, Æ Q the Semi-diameter, P the Nor. or South Pole, A the Radius of any Parallel of Lat. which is to the Semi-diameter of the Equator, as the Sine of the Arch P S to the Sine of the Arch P Æ; *i. e.* as Æ Q to Q N. Draw the Sine S N and its Co-ſine S A, alſo the Tangent Æ T, and Secant Q T. Then Q Æ = Q S is the Radius.

Demonſtration.

As Co-ſine .. Rad. :: Rad. .. Secant; *i. e.*
As N Q. (=S A) .. Q S :: Q Æ .. Q T.

Thus Mr. *Wright* did by the continual Addition of the Secants of 1′ 2′ 3′ 4′ 5′, *&c.* form a Table of meridional Parts, for the Diviſion of the meridional Line, beginning at the Equator or Parallel of 00° : 00′, and continuing ſucceſſively to the Poles of the World. So the Learned Dr. *Wallis* has demonſtrated in *Philoſ. Tranſ.* N°. 176. That the Diſtance and Poſition of any Parallel (repreſenting the Lat. in the Chart) from the Equator, ſhall be to a Similar Arc of the Equator (equal to the given Lat.) as the aggregate of all the Secants in the Arc, to ſo many times the Radius.

But how to compute independantly the meredional Parts anſwering to any given Lat. or the interval between any two, was not known till the meridional Line (or Sum of the Secants) was found to be analogous or proportional, to a Scale of Logarithmic Tangents of half the Complements

ments of the Latitudes. Which was firſt diſcovered by Chance, and afterwards proved by Mr. *James Gregory*, in his *Exercitationes Geometricæ*, but with ſuch a Train of Conſequences, and Complication of Proportions, that the Evidence of the Demonſtration was in a great Meaſure loſt, and the Reader tired before he attained it.

Since which that excellent Mathematician Dr. *Halley* in *Philoſ. Tranſ.* N°. 219. has alſo proved, that the Sum of the Secants or meridian Line on the Chart is not only proportionable to the Scale of Logarithmic Tangents, but that the meridian Line is alſo a Table of the Difference of Longitude, to each Minute of Latitude on the fourth Rhumb making an Angle of 45°. with the Meridian; wherefore the Scale of Logarithmic Tangents is a Table of the Difference of Longitude, to the ſeveral Latitudes upon ſome determinate Rhumb: Hence it follows, that as the Tangent of that Rhumb, is to the Tangent of any other Rhumb; ſo is the Difference of the Log. of any two Tangents, to the Difference of Longitude on the propoſed Rhumb, intercepted between the two Latitudes, whoſe half Complements the Logarithmic Tangents did repreſent. Now if we put Unity for one Minute of Longitude, as in the common meridian Line; becauſe the Length of the Arch of 1 Minute, is 000290888, *&c.* and the Index of the *Brigg*'s Logarithms 230258, *&c.* it will be,

As 230258, *&c.* to 290888, *&c.* So is the Radius to 1,2633114, *&c.* The Natural Tangent of 51°. 38'. 9". the Angle which the Rhumb Line makes with the Meridian, under which the common Table of Tangents are the true Differences of Longitudes.

Where-

Wherefore as 1263. to 1 Minute, ſo is the Difference of the Log. Tangents of half the Comp. of the Latitude of any two Places, to their meridional Difference Lat. in Miles. If there be a meridian Line, and a Line of artificial Tangents, both graduated from the ſame Line of equal Parts, a Degree or Minute upon the Line of Tangents ſhall be double to a Degree or Minute upon this meridian Line, and the artificial Tangent of one Minute (omitting the preceding Figures) is 2527, which by the foregoing Reaſon is equal to two Minutes upon the meridian Line; therefore the half of 2527 is 1263. which will be equal to one Minute on the meridian Line.

By what hath been ſaid, it is eaſy to conceive how to make a Table of meridional Parts; or to find the meridional Difference of Latitude (or Latitude inlarg'd) between any two Latitudes, as ſhall be ſhewn a little further.

To render the Idea of the Contrivance of (the *Mercator*'s, or) *Wright*'s Chart more perceptible to the Learner, I ſhall uſe the Author's own Illuſtration, which is as followeth, *viz.* "If a Globe "with all its Meridians and Parallels poſited "in a concave Cylinder, (their Axis mutually "agreeing) be ſuppoſed to be blown like a Blad-"der, till every Part of the convex Superficies of "the Globe touch every Part of the concave "Cylinder; then ſhall each Parallel upon the "Globe attain an equal Diameter with the E-"quator or Cylinder: And then ſhall the Meri-"dians upon the Globe be every where ſo far diſtant "each from the other, as they were at the Equa-"tor; and by this Contrivance will each Part in "this concave Cylinder mutually agree with its "correſponding Part in the Globe without either "ſenſible or explicable Error. See *Wright*'s Cor-

Correction of Errors (in the Sea Chart, or *Nautical Planiſhere*) Page 9.

To make the Mercator's Chart.

To Project the (*ſo call'd*) Mercator's *Chart, for all or Part of the Globe's Superficies.*

1. FOR the *General Chart*: It is projected upon a Plain, the Meridians being parallel to each other, (which on the Globe do incline and meet in the Poles) yet the Parallels of the Latitude are contrived ſo at unequal Diſtances, that in this Projection the Rhumbs are right Lines, and the Degrees of Longitude bear the ſame Proportion to the Degrees of Latitude in any Parallel, that they do upon the Globe: Now to make a Chart to repreſent one half the Superficies of the Globe or near it; (for you cannot go quite to the Poles, becauſe there the Quantity of one Degree of Latitude is infinite) you may make Uſe of the Meridian Line, with the Line of equal Parts, (the two loweſt Lines upon *Gunter*'s Scale.) Having provided a Sheet of Paper almoſt as broad as long, (*viz.* the Breadth to contain the 180 equal Parts annexed to the meridian Line on the ſaid Scale) draw a Line croſs the Middle of it that may contain 180 equal Parts from the Scale; this Line ſo graduated ſhall repreſent the Equinoctial, and the Diviſions 180 Degrees of Longitude. Draw Lines along each Edge of the Equinoctial perpendicular, or at right Angles to it, and let theſe Lines be graduated upwards and downwards from the ſaid Equinoctial, by the Diviſions of the meridian Line, to about 85 Degrees of Latitude on each Side of the Equinoctial: Then draw Lines through every 10°.

of

of theſe unequal Diviſions parallel to the Equinoctial; and likewiſe draw Lines through each 10°. of the Equinoctial and perpendicular to it, ſo will theſe Meridians laſt drawn interſect the Parallels firſt drawn in every 10°. of Latitude and Longitude.

Then at each Corner of your Chart, you may deſcribe an Arch or Quadrant, and divide it into eight equal Parts, and draw from the Centers Rhumb Lines through the Chart, noting the North Point of the ſaid Quarters with the Flower du Luce.

And laſtly, to lay down any Iſland, Headland, or given Place, whoſe Latitude and Longitude is known by your Obſervation, or approved Tables of Latitude and Longitude.—— Take a Pair of Compaſſes, and with one Foot in the Latitude of the Place on the graduated Meridian, extend the other Foot to the neareſt Parallel or Eaſt and Weſt Line, and there let them remain; then with another Pair of Compaſſes, and one Foot in the Longitude of the Place upon the Equinoctial, extend the other to the neareſt Meridian, (or North and South Line;) then running each Pair of Compaſſes along their reſpective Lines towards each other, the moveable Points will meet in the given Longitude and Latitude, or Point where the Place given is to be laid down, and by two ſuch Charts as theſe, (which together make a Square) you may repreſent all the Superficies of the Earth, except about five Degrees of Latitude under each Pole.

To make a Chart for a particular Voyage.

This Chart is much better than the former for the Mariner's Uſe, becauſe the Gradations may be

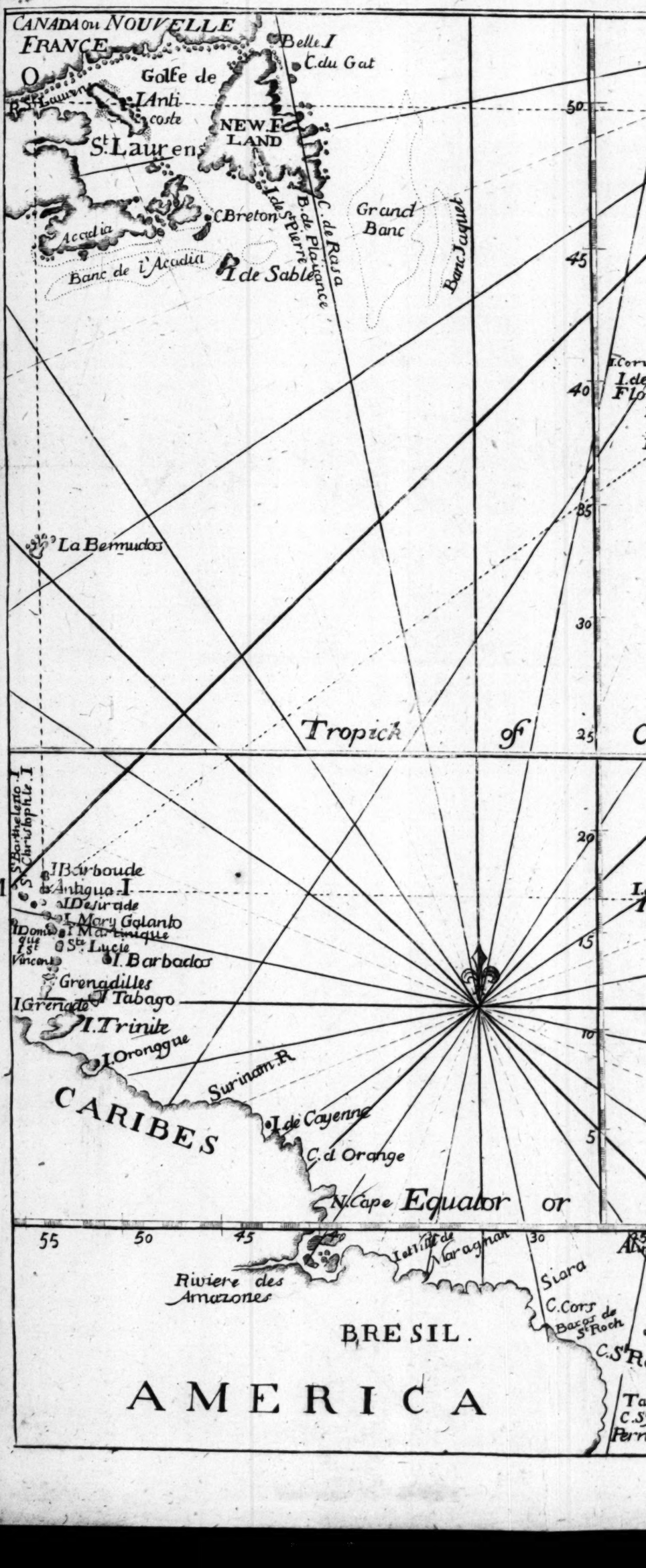
be much larger; and to make it more accurately, we ſhall uſe the Table of meridional Parts.

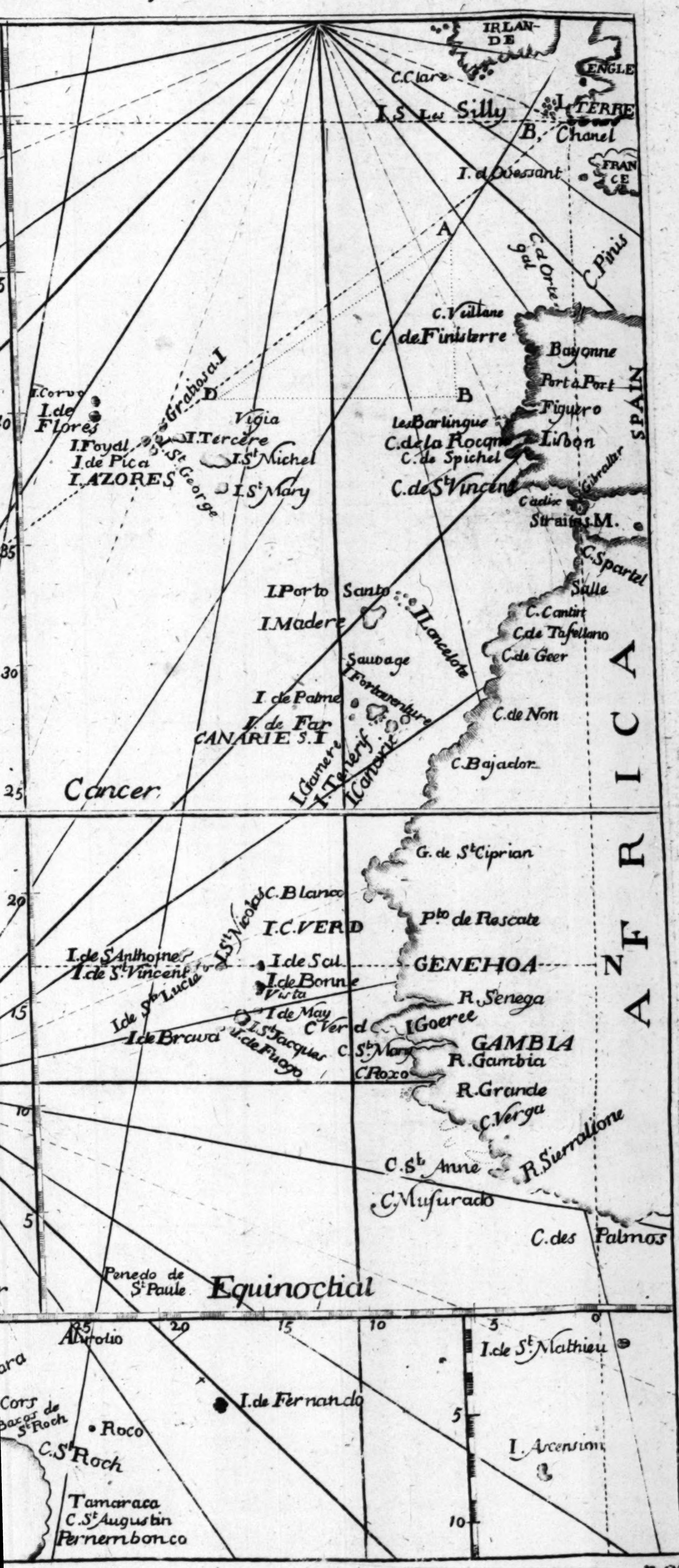
Example. Let it be required to make a *Mercator*'s Chart for a particular Voyage, *viz.* from the *Lizard* in Latitude 49°. 55′. N°. to *Antegoa*, in Latitude 17°. 00′. (or for any of the *Leward Caribee* Iſles) Difference of Longitude 54°. 07′. Weſt, or 3240 Miles, the meridional Difference of Latitude between theſe two Places being found (by the Tables) to be 2471 Miles.

Take a Sheet of ſtrong Paper, as large as you intend your Chart ſhall be; then chuſe ſome Scale of equal Parts, of which 3240 may be the Breadth, and 2471 the Length or Depth, with a convenient Allowance for Ruling, or what you think fit to draw for Ornament about the outſide of it: Then towards the North Eaſt (or upper right Hand) Corner, becauſe your Courſe is South Weſterly.

Aſſume a Point (L) for the *Lizard*, and draw a Line right down the Chart for the Meridian of the *Lizard*, upon which ſet the meridional Difference of Latitude 2471 from the *Lizard Point* down the Meridian, to a Point N. on which erect a Perpendicular to the Weſtward, and ſet off the Difference of Longitude 3240 from N. to M. and this Line, (if you will not make the Chart to the Equinoctial) you may divide into every Degree, or every 2°. Degree, or equal Parts; finiſh your Oblong, with the other two Sides or Limits of your Chart. Draw a Line down the Middle of your Chart, for the Meridian (to be graduated) which you muſt thus divide the meridional Parts (or meridional *x*. Lat.) between the *Lizard*'s Latitude 49°. 55′. and next leſſer Degree, *viz.* 49°. is 85 equal Parts ſet off on the ſaid Meridian, from the Parallel of the *Lizard* or Top of the Chart downward for 49°. of Lat.

Again,


CANADA ou NOUVELLE FRANCE
Belle I
C. du Gat
Golfe de
I. Anti coste
NEW. F. LAND
St. Laurens
C. Breton
Acadia
Banc de l'Acadia
I. de Sable
I. de St. Pierre
B. de Plaisance
C. de Rasa
Grand Banc
Banc Jaquet
La Bermudos
Tropick of
I. Barboude
Antigua I.
I. Desirade
I. Mary Galanto
I. Martinique
St. Lucie
I. Barbados
Grenadilles
I. Tabago
I. Grenade
I. Trinite
I. Orongue
Surinam R.
CARIBES
I. de Cayenne
C. d Orange
N. Cape
Equator
Riviere des Amazones
BRESIL.
AMERICA
Siara
C. Cors
Bacor de St. Roch
50
45
40
35
30
25
20
15
10
5
55
50
45
30


IRLANDE
ENGLE
TERRE
FRANCE
C.Clare
I.S. Les Silly
B. Chanel
I. d'Ouessant
A
C.d'Ortegal
C.Pinis
C. Villane
C. de Finisterre
Bayonne
Port a Port
Figuero
Lisbon
SPAIN
Gibraltar
Cadize
Straits M.
B
D
Grahosa.I
I.Corvo
I.de Flores
I.Foyal
I.de Pica
I.AZORES
I.Tercere
Vigia
I.St Michel
I.St Mary
St George
les Barlingue
C.de la Rocque
C. de Spichel
C.de St Vincent
C.Spartel
Salle
I.Porto Santo
I.Madere
I.Lancelote
C. Cantin
C.de Tafellano
C.de Geer
Sauvage
I.Fortaventure
I. de Palme
I. de Far
CANARIE S.I
I.Gamere
I.Tenerif
I.Canarie
C.de Non
C.Bajador
Cancer
AFRICA
G. de St Ciprian
C.Blanco
I.C.VERD
Pto de Rescate
GENEHOA
I.St Nicolas
I.de St Anthoine
I.de St Vincent
I.de Sal
I.de Bonne Vista
I.de St Lucie
I.de May
I.de Brawa
I.St Jacques
I.de Fugo
C.Verd
I.Goeree
R.Senega
GAMBIA
C. St Mary
R.Gambia
C.Roxo
R.Grande
C.Verga
C.St Anne
R.Sierraliona
C.Musurado
C.des Palmos
Penedo de St Paule
Equinoctial
Abrolio
I.de St Mathieu
I.de Fernando
Roco
C.St Roch
I. Ascension
Tamaraca
C.St Augustin
Pernernbonco
35
30
25
20
15
10
5
0

Again, find the meridional *x*. Lat. between 49° 5°, and 48°. which is 175 min. and ſet it off rom the ſaid Point of parallel on the Meridian ownward, and it ſhall mark out the 48°. of at. and ſo proceed with the reſt, which you may umber with Figures on the graduated Meridian, nd thro' every 5° or 10° draw Lines parallel to he Top or Bottom of your Chart, for the Paral-els of Latitude; and for the other Meridians, raw Parallels to the Sides of the Chart, or to he graduated Meridian thro' every 5° or 10° of ongitude, on the Bottom, or Equinoctial Line. nd you may deſcribe the Rhumbs or ſmall Com-aſs Chards, at any Places or Corners of the Chart. nd then, laſtly, for laying down any Head ands, you may, by the Directions given in mak-n the general Chart, lay them down in their pro-er Places. And theſe Charts are much more onvenient for the Navigator's Uſe than even the lobe itſelf, on which the Rhumbs are Spirals, r crooked, and the Diſtances of Places the rch of a great Circle. I therefore proceed to he Uſe of this Chart in Navigation. And,

1. To find the Latitude of any Place in the hart.

2. To find the Courſe or Bearing of any two laces in the Chart.

Theſe two Problems are perform'd the ſame ay on this Chart, as before ſhewn in Prob. 1. nd 3d. of the Uſe of the plain Chart, and needs o Examples.

3. To find the Longitude of any Place in the hart.

Rule 1. Take the neareſt Diſtance from the propoſed Place to any Meridian. 2. Move the ompaſſes (being kept at that Diſtance) with one oot on the Meridian, till both Feet come on he Equinoctial, and the Foot which ſtood on

the

the propoſed Place ſheweth its Longitude requir'd. So the *Lizard*, by this Rule, will be found in the Longitude of 5°: 23′ Weſt, if the Longitude is counted from the Meridian of *London*, but in 00° 00′ if counted from the Meridian of the *Lizard*.

4. To find the Diſtance of any two Places in the Chart.

This admits of four Caſes, *viz.* 1. When the two Places are under one Meridian, that is, bear North and South of each other.

Rule. Find the Latitudes of the two Places by *Prob.* 1. of this Chart, and then the Difference of Latitude between them, as found in Page 44, and 45, is the Diſtance required. So that the Diſtance between Cape St. *Vincent* in *Spain*, in Latitude 37°: 15′, N°. and *Cape Cantin*, in *Barbary*, Lat. 32°: 42′ N°. is 4°: 33′. or 273 Miles.

2. When two Places are upon the Equator or Equinoctial, (they bear Eaſt or Weſt) to find their Diſtance.

Rule. Find the Difference of Longitude between them, (as is ſhewn a little farther) and its the Diſtance required. This is ſo eaſy that it needs no Example.

3. When the two Places bear Eaſt and Weſt in one Latitude or Parallel, to find their Diſtance.

Rule 1. Take the Diſtance between the two Places in the Compaſſes. 2. Lay that Diſtance on the graduated Meridian, ſo that one Foot may be as many Degrees above the Latitude of the given Places, as the other below it; there ſtay the Compaſſes. 3. Count the Degrees between the Feet of the Compaſſes, and it's the Diſtance required.

Or thus, Take the Length of a Degree in the given Latitude, turn that over in a ſtrait Line from one Place to another, as many times as you

can

tan gives the Number of Degrees for the Diſtance as before. So Cape *Roxant*, going into *Lisbon*, and the Iſle *Pico* one of the Weſtern Iſles, are in the Latitude of 38° ½ will be found by the former Rules to be 13°. or 260 Leagues diſtant.

4. When two Places differ both in Latitude and Longitude to find their Diſtance.

Rule 1. Take their Difference of Latitude from the Equinoctial.

2. Lay a Ruler on both the given Places, apply that Diſtance ſo to the Ruler's Edge, that when one Foot is placed cloſe to the Ruler, and the other turned about, it may juſt touch ſome Eaſt and Weſt Line croſs'd by the ſaid Ruler's Edge, there ſtay the Compaſſes.

3. Then the Diſtance (by the Ruler's Edge) from the Place where the Compaſſes reſted, to the Place where the Ruler croſſeth the aforeſaid Eaſt and Weſt Line meaſured on the Equinoctial, giveth the Diſtance required.

Thus to find the Diſtance from the *Lizard* to *Antegoa*,

	°	′	
The *Lizard's* Latitude is—— ——	49	: 55	N.
Antegoa's Latitude is —— ——	17	: 15	N.
Their *x.* Latitude is,——————	32	: 40	

Which taken in your Compaſſes from the Equinoctial, (and the Ruler laid over the *Lizard*) and applied as before, and meaſured on the Equinoctial again, gives 56°.4′. or 112.4 Leagues the Diſtance required.

5. The Latitude and Longitude of the Ship, given to find the Point, or Place of the Ship repreſented in the Chart; this is of great Uſe to ſhew the Mariner what head Lands or Iſlands are near him in his Voyage, *&c.* and this Problem is per-

formed after the ſame manner as was directed in Page 91, of laying down any head Land or Place on the general *Mercator*'s Chart; therefore if we ſuppoſe when at Sea, you find by your Journal or Reckoning (at Noon) you were in the the Latitude of 40°. 30'. North, and Longitude from *Lizard* 17°- 20'. (or from the Meridian of *London* 22°. 33'. W. according to which Meridian of the two you count Longitude from) by the foreſaid Rule, the Ship will be found at the Point D. near unto the *Azores* or Weſtern Iſlands *Tercera*, *Gratioſa*, *&c.*

Thus may you prick down the Place of your Ship any (or every Day) at Noon, and drawing Lines from Point to Point, from the Place you departed from, (with a Black-Lead Pencil, which may be wiped out at Pleaſure) you will have the Tract the Ship hath made at the End of every 24 Hours during the whole Voyage.

The finding the Diſtance of two Places differing in Latitude and Longitude with a little Practice, will be found very eaſy; yet, to make it yet more quick and eaſy in Practice, ſome Authors have oblig'd us with Scales for meaſuring the ſaid Diſtance in a *Merchator*'s Chart; as Capt. *Sturmy*'s *Magazine*, Page 120. Mr. *Wilſon*'s Addition to *Practical Navigation*, Page 187. Mr. *Haſeldon*'s Deſcripion and Uſe of *Mercator's* Chart, Page 27. but I conceive that they are of no Uſe at all to the Mariner, except they were inſerted in every particular *Mercator*'s Chart the Mariner Buys.

I paſs on to (*Mercator*'s or rather) *Wright*'s Sailing by Conſtruction and Calculation.

Primary

Primary Problems.

Prob. 1. *Given, the Latitude of two Places; required the meridional Difference of Latitude between those two Places.*

WE ſhall ſolve this Problem both by the Table of meridional Parts, and Table of Log. Tangents, the one being the certain Proof of the other.

1. To find the meridional Parts out of the Table of meridional Parts for any Latitude.

I demand the meridional Parts for the Latitude of 49°. 55′? (North or South) right againſt 49°. (in the firſt Column) and under 55 Min. (at the Head of the Table) you will find 3467; which is the meridional Parts in Miles, anſwering the Latitude as was required.

Since this Table is calculated but to every five Minutes or Miles of Latitude, you have at the End of it annex'd a Table of proportional Parts, by the Help of which you may find the meridional Parts to every Minute of Latitude.

Example. *What's the meridional Parts for the Latitude of* 16°. 29′. ?

The next leſs than 29′. is 25; wherefore finding the meridional Parts for 16°. 25 to be 999, and right againſt 16 Degrees in the Column of Difference you will find 5, look this Difference in the firſt Column under (D) of the Table of Proportional Parts, and find 4 (the Difference between 29′. and 25′.) at the Head of the Table; then right againſt 5, and under 4, you will find the proportional Part 4; which added to 999, makes 1003, the meridional Parts for the Latitude of 16°. 29′. required.

Then observe this Rule.

Latitudes both North or both South, ſubtract; but one Latitude North and the other South, add the meridional Parts, and the Difference or Sum is the meridional *x.* Latitude required.

Example. 1. *What's the meridional x. Latitude between the* Lizard, *Latitude* 49°. 55'. *North, and* Madera *in Latitude* 32°. 25'. *North.*

	Merid. Parts
From	3467
Subtract	2058
Rem. is = merid. *x.* Lat.	1409 Miles

By the Log. Tangents.

Rule. The Diff. of the Tangents (or Co. Tangents) of half the Comp. Latitudes divided by 1263, gives the meridional *x.* Lat. in Miles.

		° ′		° ′	
Lat.	*Lizard*	49 : 55	½ Co.	20 : 02½	.956 1851
	Madera	32 : 25	Lat. =	28 : 47½	.973 9870
				Diff. =	178019

1263)178019.(1409=meridional *x.* Lat.

Exam. 2. *If one Place hath a Lat. the other none; (that is on the Equator) Suppoſe* Surrat *and the Iſland* St. Thomas, *what is their Merid. x. Latit.*

		° ′		Miles
Lat.	*Surrat*	21 : 10 N.	Meridional Parts	1300
	St. Thomas	00 : 00		0000
Remainder = meridional *x.* Latitude				1300

By Log. Tangents.

Rule. The Diff. between the Tangents (or Co. Tangents) of half the Comp. Lat. and the Tang. of 45° (= Radius or 10.000000.) divided by 1263. gives

gives the meridional Difference of Latitude in Miles.

		° ′		° ′	
Lat.	*Surrat*	21 : 10	Co. Lat.	34 : 25	9.835780
	St. Thomas	00 : 00	T.	45°.00	10.000000
				Diffs. =	164220

1263)164220(1300 = merid. *x.* Lat.

Exam. 3. *In Latitudes of different Kind (one North the other South) ſuppoſe* Antegoa, *and Cape* Bon. Eſperance, *What is their merid. x. Lat.*

			° ′	
To 1051	Merid Parts	*Antegoa*	17 : 15	N°.
Add 2192	in Lat.	*C. Bon. Eſp.*	34 : 15	S°.

Sum 3243 = meridional *x.* Latitude required.

By Log. Tangents.

Rule. The Sum of the Differences between the Tang. 45°. and the Tang. (or C°. Tang.) of half Co. Lat. divided by 1263, is equal to the meridional *x.* Lat.

		° ′		° ′	
Lat.	*Antegoa*	17 : 15	½ Co. Lat.	36 : 22	10.132906
	C. B. Eſp.	34 : 15		27.52	10.276768
				Sum =	409674

1263)409674(3243 = meridional *x.* Lat. required.

The Merid. x. Lat. may be alſo found by Gunter's *Scale, Thus;*

The Extent of the Compaſſer from one Lat. to another, on the meridian Line, will give meridional *x.* Lat. in Deg. and Min. on the Equinoctial Line or Line of equal Parts. That multiplied by 60, adding the odd Minutes (if there be any) gives the meridional *x.* Latitude in Miles.

Prob. 2. *Given*; *The Longitude of two Places*; *required their Difference of Longitude?*

Rule. In Longitudes of the ſame Name (that is both East or both Weſt) their Difference; but of contrary Names (that is one East t'other Weſt) their Sum is the Difference of Longitude required.

Note. If that Sum exceed 180°. ſubtract it from 360°. and the Remainder is the Difference of Long.

Exam. 1. *What's the Difference of Longitude between* Madera *Iſle, and the Iſland of* Antegoa.

			°	′	
From }	the Longitude of	*Antegoa*	61	44	W.
Subt. }		*Madera*	17	42	W.
Remainder = *x.* Longitude required			44	02	
			60		
Or reduced is =			2642	Miles.	

Exam. 2. *Required the x. Longitude between* Barbadoes *and Cape* Negro?

			°	′	
To }	the Longitude of	*Barbadoes*	58	32	W.
Add }		Cape *Negro*	14	26	E.
Sum = *x.* Longitude required			72	58	

Exam. 3. *Required the x. Longitude between the River* Canton *in* India, *and the Weſt-end of* Jamaica *in the* Weſt-Indies.

			°	′	
To }	the Longit. of	R. *Canton*	114	00	E.
Add }		*Jamaica*	77	12	W.
Sum			191	12	
Subtract from			360	00	
Remainder is = *x.* Longitude			168	48	

Prob. 3.

Prob. 3. *Given the Longitude of one Place, and the x. Longitude between that and another; required the Longitude of that laſt Place?*

Rule, *Caſe* 1. If the given Longitude and *x.* of Longitude be of the ſame kind, (*viz.* both Eaſt or both Weſt) their Sum is the Longitude required of the ſame Name with the firſt Place.

Note: If the Sum be more than 180°. its Complement to 360°. is the Longitude requir'd, of contrary Name with that of the firſt Place.

Caſe 2. But if the given Longitude and *x.* Longitude be of different kind, (that is one Eaſt and the other Weſt,) their Difference is the Longitude required of the ſame Name with the greateſt.

Exam. 1. *Suppoſe from the Longitude of (the* Lizard) 5°. 23'. W. *A Ship ſails Weſterly, till her x. Longitude be* 35°. 45'. W. *I demand the Lon-gitude ſhe is in?*

By Caſe 1.

To the departed	} Longitude	{ 5	: 23	W.
Add the Diff.		{ 35	: 45	W.
Sum is the preſent		40	: 08	W.

Exam. 2. *If from the Longitude of* 143°. 20. W. *a Ship ſails Weſterly till the x. Longitude be* 55°. 40'. W. *what Longitude is ſhe in?*

By Caſe 1,

To the departed	} Longitude	{ 143	: 20	W.
Add the Diff. of		{ 55	: 40	W.
Sum is		199	: 00	
Subtract from		360	: 00	
Rem. = preſent Longitude		161	: 00	E.

Exam. 3. *Suppoſe from the Longitude of* 56°. 30'. W. *a Ship ſails eaſterly, 'till the Difference of Longitude be* 33°. 45'. E. *I demand the preſent Longitude?*

By Caſe 2.

From departed	} Longitude	56°	30' W.
Subtract Difference		33	45 E.
Rem.= preſent		22	45 W.

Prob. 4. *Caſe* 1. Given, the Latitude and Longitude of two Places, required their Courſe (Bearings) Diſtance and Departure (or meridional Diſtance.)

Exam. *A Ship takes her Departure from the* Lizard *in Latitude of* 49°. 55', N. *and* 5°. 23'. W. *Long. being bound to Antegoa in Lat.* 17°. 15'. N. *and Long.* 61°. 44'. W. *what Courſe muſt ſhe ſteer, and what Diſtance (and Weſting) muſt ſhe make upon a ſtrait Line to the Iſland?*

Preparation.

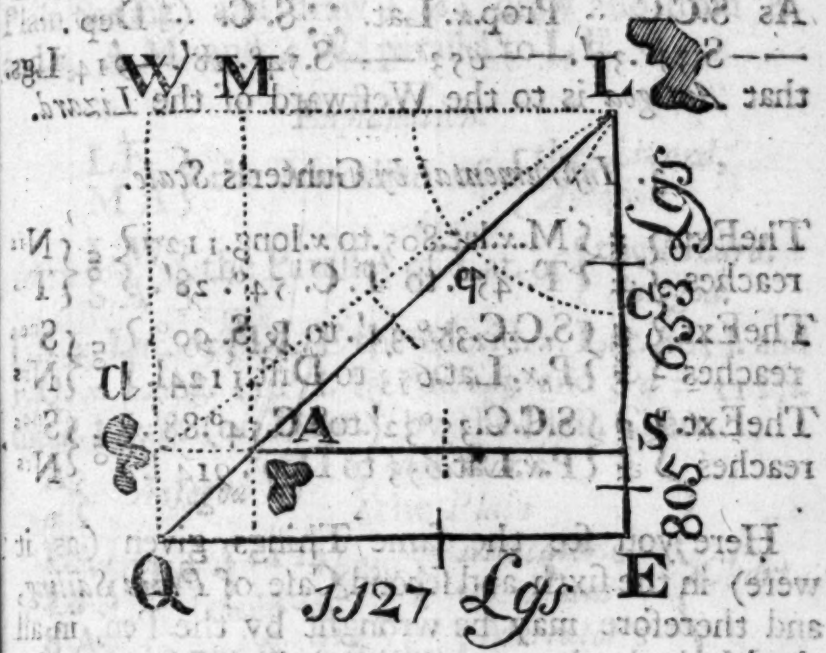
	°	'				°	'
From	39:	55 N	Lat.	*Liz.* M.	3467	Long. 5:	23 W.
Subt.	17:	15 N		*Ant.* P.	1051	61:	44 W.
Rem.	32:	40	Mer. *x.* Lat. =		2416		56:21
		60	Take $\frac{1}{3}$		805 Lg.		60
	m 1960 = *x.* Lat.			*x.* Long.		3381 m.	
	3) 653 Leagues					3) 1127 Lgs.	

1. *Conſtruction Geometrically.*

Draw L E for the Meridian of the *Lizard*, and on it from L. ſet off the meridional *x.* Lat. 805 l. to E, alſo the proper *x.* Lat. 653 l. from L. to S.

2. Erect

2. Erect a Perpendicular from E towards Q, and ſet on it from E the *x*. Long. 1127 l. (=Parts) to Q and draw the Line Q L.



3. Draw from S, S A. parallel to the *x*. Longitude E Q.

4. With a Chord of 60′. on the Point L deſcribe an Arch *c q*.

Explanation. A repreſents *Antegoa*, L the *Lizard*, S A the Departure, L A the Diſt. the Arch *c q*, or ∠ at L the Courſe (S°. weſterly) from the *Lizard* to *Antegoa*.

Menſuration. L A and S A meaſured on the equal Parts ſeverally, gives 1124 l. for the Diſtance, and 914 l. for the Departure; alſo the Arch *c q* meaſured on the Chords, gives S. 54°. 28′ W. for the Courſe, from the *Lizard* to *Antegoa* by *Mercator*'s or the true Chart.

2. *Logarithmetically.*

(As the ſixth Caſe of *Plain Sailing*.)

As Mer. *x*. Lat. .. R :: *x*. Long. T. Courſe.

—— 805 —— T. 45 —— 1127 —— S. 54°. 28′. W.

As

Then as in Case 2. *Plain Sailing.*

As S.C.C. .. Prop. *x.* Lat. :: R .. Dist.
——S. 35°.32′. ——653 —— S. 90 —— 1124 Leag.
As S.C.C. .. Prop. *x.* Lat. :: S.C. .. Dep^r.
——S. 35°.32′. ——653 —— S. 54°.28′. —— 914 Lgs.
that *Antegoa* is to the Westward of the *Lizard.*

3. *Instrumental by* Gunter's *Scale.*

The Ext. reaches } from { M. *x.* lat. 805. to *x.* long. 1127 } on { N^rs / T^rs
from { T. 45°. to T. C. 54°. 28′. }

The Ext. reaches } from { S.C.C. 35°.32′. to R. S. 90°. } on { S^nes / N^rs
from { P. *x.* Lat. 653 to Dist. 1124 l. }

The Ext. reaches } from { S.C.C. 35°32′. to S.C. 54°.88′. } on { S^nes / N^rs
from { P. *x.* Lat. 653 to Dep^r. 914 l. }

Here you see the same Things given (as it were) in the sixth and second Case of *Plain Sailing*, and therefore may be wrought by the Pen, in all the Methods there treated of, which I leave to the Industry of the Learner, as I shall also the following Cases; only you may here observe, that in this and other Cases of *Mercator*'s Sailing, we have two similar Triangles to solve, and therefore by 4. 6 Euclid, they are proportional, like Sides, to like Sides. For as L E (the meridional *x.* Lat.) is to E O (the *x.* Long.) so is L S. (the Prop. *x.* Lat.) to S A (the Dep^r.) the Course and Distance is found (*Arithmetically*) by Case 6. of *Plain Sailing.*

Use of this Case, is when we depart from any Head Land, *&c.* to know the Course and Distance to any other Place; which is required at the Beginning of your Voyage, and of the keeping your Sea Journal.

We shall in this Problem also shew the Defects of the *Plain Chart* or *Plain Sailing*, and exhibit the Verity of the *Mercator*'s Chart or *Plain Sailing* rectified by the Globe.

A *Constru-*

Construction. Make S *a* = E Q. (because the *x.* Longitude and Departure, are the same thing in Plain Sailing) and draw L *a*; draw also from A, and *a*, A M. and *a* W. parallel to L E.

Explanation.

L E } the Meridian of { the *Lizard*,
M A } { *Antegoa.*

L W } the Parallel of Lat. of { the *Lizard.*
S A } { *Antegoa.*

L S. *x.* Lat. 653 l. L E the Merid. *x.* Lat. 805 l. and E Q. *x.* Long. 1127 l. by *Mercat.* and S *a* = 1127 *l.* the *x.* Long. (or Dep^{r}.) by the Plain Chart.

A } *Antegoa* by { *Mercator's* / the *Plain* }
a }

L A } Dist. { 1124 } by { *Mercator's* / the *Plain* } *Chart.*
L *a* } { 1803 }

S A } Dep^{r}. { 914 } by { *Mercator's* / the *Plain* }
S *a* } { 1127 }

∠ L A S } Course { *Mercator's* } *Chart* { S. 54: 28 W
∠ L *a* S } by { the *Plain* } { S. 55: 55 W

So that it is plain, the *Plain Chart* (or *Plain Sailing*) is erroneous, in the Course 5°. 27′. or half a Point more Westerly; in the Distance 79 Leagues, and in the meridional Dist. Departure or Westing 213 Leagues, from the *Mercator's* or true Chart in the foresaid Voyage.

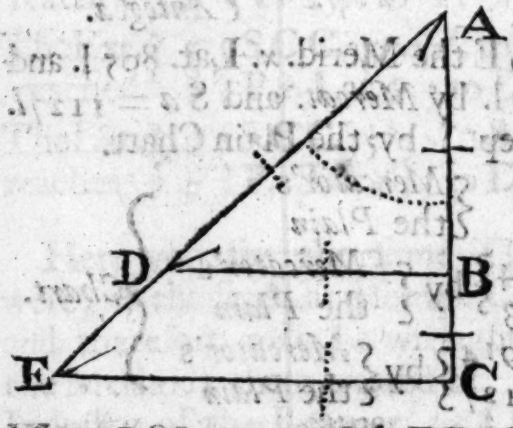
Prob. 5. *Case* 2. Given Latitude and Course; required Dist. Dep^{r}. and *x.* Long.

Exam. *Sailing by the Log. (since Yesterday) Variation and Lee Way,* &c. *(allowed for)* S. W. by W. *and the Latitude of Yesterday was* 48°. 50′. N. *and to Day by Observation the Ship is in Lat.* 47°. 10′. N. *What is the Distance run, Departure (or Westing,) and x. Longitude?*

Prep,

	° ′			
Prsp. From	48 : 50 N	merid. Parts	3367	
Subt.	47 : 10 N		3217	
	1 : 40	Mer. *x.* Lat. =	150 m.	
	60			
x. Lat =	100 m.			

Construction.



1. Construct the Triangle ABC, by the Course and *x.* Lat. according to the second Case of *Plain Sailing.*

2. Make AC equal to the meridional *x.* Latitude 150m. (=Parts,) and draw EC. (the *x.* Long.) parallel to DB the Departure, till it meet the Distance AD produced in E. Then is AD the Distance sailed = 178m. BD = the Departure 150m and CE = 224m. the *x.* Longitude, when measur'd by a Scale of equal Parts.

As Case 2. *Plain Sailing. Calculation by Logar.*

As S.C.C. .. P. *x.* Lat :: R .. Distance
—S. 33°. 45′.—100m.—S. 90°.—178 Miles.

2. As S.C.C. .. P. *x.* Lat. :: S.C. .. Depr.
— S. 33°. 45′.— 100m —S. 56°. 15′—150 mil.

3. As S. C.C. .. Mer. *x.* Lat. :: S. C. .. Long.
— S. 33°. 45 — 150m. —56°. 15′. —224 miles

Or,

As R .. Mer. *x.* Lat. :: T. C. .. *x* Long.
T. 45°——150——56°. 15′. —— 224 Miles

Or

As P. *x.* L. .. Mer. *x* Lat. :: Depr. *x.* Long.
—100m———150——150——224 Miles

3. *In-*

3. *Instrumental by* Gunter's *Scale.*

The Ext. reaches } from from { S.C.C. 33°.45'. to R. S. 90'. / P. *x.* Lat. 100^{m}. to Dif. 178^{m} } on { S^{ns} / N^{rs}

The Ext reaches } from from { S.C.C 33°.45'. to S.C. 56°.15 / P. *x.* Lat. 100^{m}. to Dep. 150^{m} } on { S^{ns} / N^{rs}

The Ext reaches } from from { S.C.C 33°.45 to S.C. 56°.15 / M. *x.* lat. 150^{m}. to *x.* long 224^{m} } on { S^{ns} / N^{r}

Prob. 6. Case 3.

Given Latitudes and Distance; required Course, Departure, and x. Longitude, sailing North-westward from Cape St. Vincent *in* Portugal 300 *Miles, until by Observation the Ship is in Lat.* 21°. 00'N. *What's the Course steer'd, Departure, and Longitude the Ship is in?*

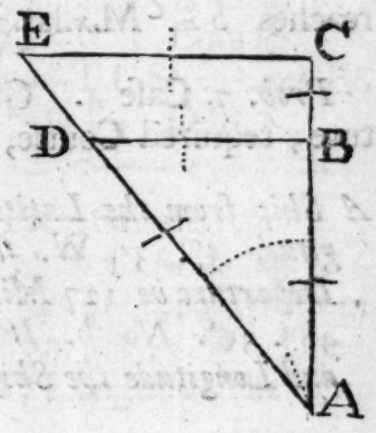
Preparation.

			Mer. Parts	Longit.
From	41 : 00 N.	Lat.	2702	10°.35'. W
Subt.	37 : 15 N.		2411	4 : 17 W
Miles	3 : 45	Mer. *x.* Lat.	291	Long. 14:52 W
	60			
	225 = P. *x.* Lat.			

1. *Construction.*

1. With the *x.* Latitude 225 = Parts and Distance 300 = Parts project the Triangle A B C by Case 4. *Plain-Sailing.*

2. Let AC be made equal to the meridional *x.* Lat. 291 = Parts, and erect the Perpendicular C E till it meet with A D. continued in E,



then

then is B D the Departure = to 198^{m}. and C E =257^{m}. being measured on the Scale of equal Parts, also the Angle B A D the Course, the Arch of which Angle, on the Chords is = 48°. 35′.

2. *Logarithmetical, By* Case 4. P. S.

As Dist. .. R :: P. *x.* Lat. .. S. C. Course
—300^{m}—S. 90°———225——48°. 35′. Comp. to 90°. is N. 41°. 25′. W. the Course steer'd.

As R .. Dist. :: S. C. .. Departure
—S. 90——300——S. 41°. 25′——198^{m}.

As S. C. C. .. Mer. *x.* Lat. :: S. C. .. *x.* Long.
—S. 48°. 35′.———291^{m}——S. 41°. 25′.——257^{m}.

You may find the *x.* Longit. two other ways by (Case 2. foregoing) the *x.* Long. reduced to Degrees and Minutes is 4°. 17′. W. which added to the Longitude sailed from gives the Longitude the Ship is in, as you see annex'd to the Preparation.

By Gunter's Scale.

The Ext. reaches } from { Dist. 300^{m}. to P. *x.* lat. 225^{m}. / R S. 90°. to S. C. C. 48°. 35′ } on { N^{rs} / S^{nes}.

The Ext. reaches } from { R S. 90°. to S. C. 41°. 25′. / Dist^{s}. 300^{m}. to Dep^{r}. 198. } on { Sines. / N^{rs}.

The Ext. reaches } from { S. C. C. 48°. 35′. to S. C. 41°. 25′ / M. *x.* lat. 291^{m}. to *x.* long. 257 } on { S^{nes} / N^{rs}

Prob. 7. Case 4. Given Latitudes and Departure; required Course, Dist. and *x.* Longitude.

A Ship from the Latitude of 50°. 00′. N. *and Longitude* 5°. 23′. W. *sails South Eusterly till her Departure be* 127 *Miles, and the observ'd Lat. be* 48°. 30′. *North. What is the Course, Distance and Longitude the Ship is in?*

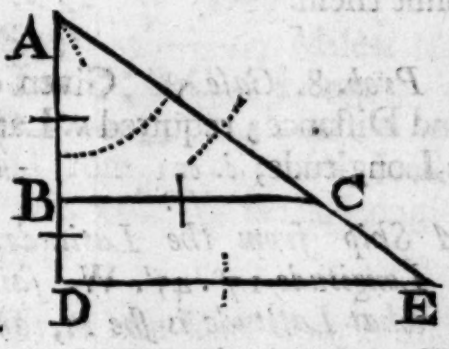
Prepa-

Preparation.

	°. ′.		Mer. Parts		°. ′.
From 59 : 00 N.			2475		5 : 23 W.
Subt. 48 : 30 N.			3337		3 : 13 E. *x.*
	1 : 30	M. *x.* Lat.	138 m.		2 : 10 W. in
	60				
x. Lat. 90 m.					

By Case 6. Plain Sailing.

Construct. With the *x.* Latitude 90m. and and Departure 127m. project the Triangle A B C, produce A B, and make A D = the meridional *x.* Lat. 138m. = Parts.



2. Draw D E parallel to B C the Departure and produce A C to E; so shall D E be = the *x.* Long. A C the Dist. the former = 193m. and the latter = 156m. when severally measured by a Scale of equal Parts; likewise the Arch of the Angle of the Course measur'd on the Line of Chords is = S. 54° 2. E for the Course required.

Logarithmetical by Case 6. Plain Sailing.

As *x.* Lat. .. R :: Depr. .. T. Course.
——90.——T. 45°.——127m.—T.C.S°.54°.3c′.Et.
As S.C. .. Lepr. :: R .. Dists.
——S. 54°. 0′. ——127m——S.90——156 Miles

Then by Case 5. Plain Sailing.

As S.C.C. .. Mer. *x.* Lat. :: S. C. .. Long.
—S. 35°. 30′.——138m.—S. 54°. 30′ = 193 Miles or 3°. 1′. which subtracted from 5°. 23 W. Long. sailed from, gives 2°. 1c. W. Longitude the Ship is come into.

I judge

I judge it needleſs to ſet down any more Extenſions by *Gunter*'s Scale in this Sailing, ſince it's ſo obvious to a diligent Learner: If he obſerves the General Rule, of extending the Compaſſes from the firſt Term to the third, (in any Proportion) will reach from the ſecond Term to the fourth Term required.

Theſe four laſt Caſes are only of uſe at Sea, (where we have always two Latitudes given) but ſince it is cuſtomary, to work the other Caſes wherein one Latitude only is given, I ſhall not omit them.

Prob. 8. *Caſe* 5. Given one Latitude Courſe and Diſtance; required *x*. Latitude, Departure, and *x* Longitude, *i. e.*

A Ship from the Latitude of 15°. 15. N°. *and Longitude* 17°. 45'. W. *ſails* N. E. by N. 120^{m}. *what Latitude is ſhe in, and what's her Eaſting, and Longitude arrived into?*

Projection.

1. With the Courſe 3 P. or 33°. 45'. and Diſt. 120^{m}. Conſtruct the Triangle A B C, by Caſe the firſt of *Plain Sailing*, Meth. 1.

2. The Departure and *x*. Latitude is meaſured as there directed. Then.

Logarithmetic. by Caſe 1. Plain Sailing.

As R .. Diſt. :: S. C. C. .. *x*. Lat.
—— S. 90 —— 120^{m}. —— S. 56°. 15'. —— 100 Miles,
or 1°. 40'. Northerly. Then

To

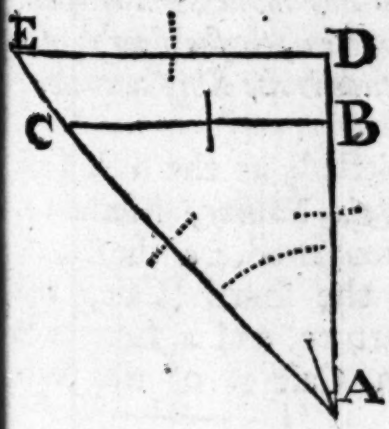
	°	′		
To Latitude	15	15	N.	926
Add *x.* Latitude	1	40	Northerly.	
Z. = Latitude in	16	55	N.	1030

104 = Mer. *x.* Lat. which ſet off from A to D, and draw DE parallel to BC, till it meet with AC. produc'd in E. So ſhall DE be the Alteration of Longitude. Then ſay;

As R .. Diſt. :: S. C. .. Depr.
—S. 90— 120m. —S. 33°. 45′.—67 Miles.
As S. C. C. .. Mer. *x.* Lat. :: S. C. *x* Long.
—S. 56°. 15′.—104m—33° : 45′.—69m. or 1°. 9′. E which deducted from 17°. 45′. W. Longitude, the Remainder 16°. 35′. W. is the Longitude the Ship is come into.

Prob. 9. *Caſe* 6. Given one Lat. Courſe and Departure; required the other Latitude, Diſtance, and *x.* Longitude.

A Ship from the Lat. of 34°. 30′. S°. *and Long.* 12°. 14′. E. *ſails* N. W. ½ *W. until her Weſting or Departure be* 95m. *What Diſtance hath ſhe run, and what Lat. and Longitude is ſhe come into?*



Conſtructed, as Caſe 3. Meth. 1. of *Plain Sailing*. And the required Sides, the Diſt. *x.* Latitude and *x.* Longitude meaſured from the ſame Scale of equal Parts you protracted BC.

Logarithmetic. by Caſe 3. of Plain Sailing.

As S. C. .. Dep^{r}. :: S. C. C. .. *x.* Lat.
—S 50°.38′.—95^{m}.—S.39°.22′.—78^{m}.or 1°.18′.N.

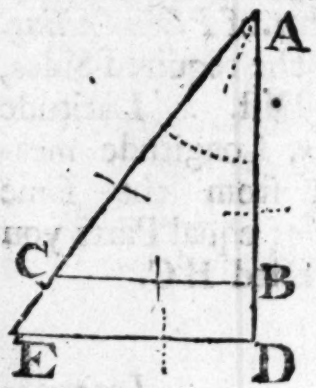
		Mer. Pts.
Then from Lat.	34 : 30 S.	2208
Subtract *x.* Lat.	1 : 18 N.	
Rem. preſent Lat.	33 : 12 S	2114
Meridional *x* Lat.	=	94 m.

Which ſet from A to D, and proceed as directed in the laſt Caſe.

As S. C. .. Dep^{r}. :: R. .. Diſt.
—S. 50°. 38′.—95^{m}.—S. 90°.—123 Miles.
As S.C.C. .. Mer. *x.* Lat. :: S. C. .. *x.* Long.
—S.39°. 22′.—94^{m}.—S.50°.38′.—115^{m}.or 1°.55′. W. which taken from the Longitude departed from, remains the Longitude of the Ship 10°. 19′.E.

Prob. 10. *Caſe* 7. Given one Lat. Diſt. and Dep^{r}. required other Lat. Courſe, and *x.* Long. *i.e.*

Suppoſe a Ship from the Latitude of 37°. 45′. N. *and Long. of* 15°. 30′. W. *ſails in the South-weſt Quarter* 130^{m}. *and then has made* 84^{m}. *Weſting, (or Departure) What Courſe hath ſhe ſteer'd, and what Latitude and Longitude is the Ship come into?*



Projected, as the fifth Caſe of *Plain Sailing*, Method 1. and meaſured, *i. e.* the Courſe as in the fourth Caſe, and Departure, and *x.* Longitude as in Caſe 2. of this Sailing.

Logar.

Logarithmetic. as Case 5. Plain Sailing.

As Dist. .. R :: Dep^r. .. S. Course
— 130^m.——S. 90.——84^m.——S°. 40°. 10′ W.
As R .. Dist. :: S.C.C. .. *x*. Lat.
—S. 90——130^m.——S.49°.50′. 100^m. or 1°. 40. S.

	°	′	Mer.Pts
Then from Lat. departed	37	: 45	N°.——2449
Take the *x*. Lat.	1	: 40	S.
Remainder is the Lat. in	36	: 05	N.——2324

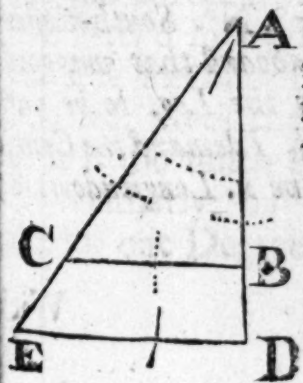
Merid. *x*. Lat. is m. 125

Then set off the meridional *x*. Latitude, and draw the *x*. Longitude Line as was directed in *Prob*. 8. *Case* 5. of this Sailing, and the Triangle is finish'd. Then say

As S.C.C. .. Mer. *x*. Lat. :: S.C. .. *x* Long.
As S. 49°. 50′.——125 ——S.40°. 10′.—105^m. or 1°. 45′. W. the *x*. Long. which added to the Longitude sailed from 18°. 30′. W. gives 20°. 15′. W. the Longitude in.

Prob. 11. *Case* 8. Given one Lat. Course and *x*. Longitude, required the other Latitude, Distance, and Departure.

Admit a Ship in the Latitude of 50°. 00′. N. *and Longitude* 5°. 30′. W. *sails* S. W. by S. *until she is in the Longitude of* 6°. 55′. W. *I demand what Latitude she is come into, with her Distance and Departure from the Meridian?*



Prep. From 6°. 55′. take 5°. 30′. remains 1°. 25′. or 85 Miles for the *x*. Longitude. Then the Question is delineated, as in *Case* 3. of *Plain Sailing*, Meth. 1. making DE equal to the *x*. Longitude, and the Angle DAE equal to the Complement of the Course.

Logarithmetic. by Caſe 3. *Plain Sailing*
As S. C. .. *x.* Long. :: S. C. C. .. Mer. *x.* Lat.
—S. 33°. 45′. ——85ᵐ. ——56°. 15′. ——128ᵐ.
Then becauſe the Ship ſailed to the Southward from a North Latitude.
From the merid. Parts anſwering 50°. 00′. N. 3475
Take the meridional *x.* Lat. Southerly = —— 128

Remains the merid. Parts of the Lat. the Ship is in 48°. 37′. as found in the Table of merid. Parts. } 3347

	°	′	
Then from Latitude ——	50	00	N.
Subtract the Lat. come into	48	37	N.
Remains the *x.* Latitude——	1	23	or 83ᵐ.

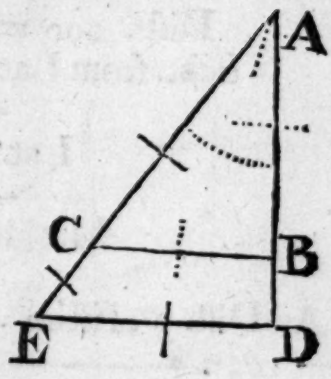
Then make A B equal to the Prop. *x.* Lat. 83 equal Parts, and draw B C the Departure, paralled to the *x.* Longitude D E, and the Queſtion is projected.

The Diſt. and Departure is found Logametic. by Caſe 2. Meth. 1. of *Plain Sailing*, viz.
As S. C. C. .. P. *x.* Lat. :: R .. Diſt.
— S. 56°. 15′.—83ᵐ. —— S. 90°——100 Miles.
As S. C. C. .. P. *x.* Lat. :: S. C. .. Depʳ.
—S. 56°. 15′——83ᵐ.——S. 33°. 45′.—55 Miles.

Prob. 12. *Caſe* 9. Given one Lat. Diſt. and Longitude, required the other Lat. Courſe and Departure.

Sailing from the Latitude of 50°. N°. *South-weſterly* 100ᵐ. *having no Compaſs aboard that was good; but knowing my Diſtance by the Log. to be* 52ᵐ. *leſs than the* Mercatoral *Diſt. I demand the Courſe Lat. in, and Departure; the x. Longitude is* 85 *Miles?*

With



With the *x*. Longitude 85 = Parts, and *Mercator*'s Diſt. 152 = Parts project the Triangle ADE. By Caſe 5. *Plain Sailing*, Meth. 1. Then, by the ſaid Caſe, 'twill be to find the Courſe by the Logarithms. Thus;

As Merc. Diſt. .. R :: *x*. Long .. S. Courſe.
—152m.——S. 90——85m——S. 33°. 45′. W.

Make AC = 100 Parts and draw CB parallel to DE, ſo ſhall CB be = Departure and AB = *x*. Lat. Then by Caſe 1. *Plain Sailing*.

As R .. Diſt. :: S. C. .. Depr.
—S. 90——100m.——S. 33°. 45′.——55 Miles

As R .. Diſt. :: S. C. C. .. *x*. Lat.
— S. 90°——100m.——S. 56°. 15′.—83m. or 1°. 23′.

Then from 50°. N°. Lat. Subt. *x*. Lat. 1°. 23′. Southerly, remains 48°. 37. N°. the Lat. the Ship is in.

Or otherwiſe thus: We may find the required Things, by only the Diſtance and *x*. Longitude given.

Rule 1. Reduce the Diſt. into Deg. and Min. and add it to the Latitude ſailed from, if you ſail Northward; but ſubtract it from the Lat. when you ſail Southward; and that gives the Latitude arriv'd in by Eſtimation.

2. The meridional Parts of the two Latitudes ſubtracted, gives the Diſtance inlarged: (AE) But it is too much in ſailing Northerly, and too little Southerly, by about 6 Miles in both Latitudes for one Degree.

	m	o	′	Mer. Pts
Dist^{s}. 100 =		1 : 46	——	3475
Subt. from Lat.		50 : 00		
Lat.		48 : 14	——	3312

Meridional *x*. Lat. ſup. 163 m.

Then,

As Dift. p^{r}. Eſtim .. ℞ :: *x*. Lon. .. S. C.
— 163^{m} —— S. 90 —— 85^{m}. — 31°. 15′.
As ℞ .. Dift. :: S. C. C. .. Lat.
— S. 90 — 100 — S. 58°. 45′. — 86^{m}. or 1°. 26′.

	o	′	Mer. Pts.
Lat. ſail'd from	50 :	00 N.	
x. Lat ——	1 :	26 S.	— 3475
Lat. come into	48 :	34 N.	—— 3343

Meridional *x*. Lat. m. 132

As ℞ .. Dift. :: S. C. .. Dep^{r}.
— S. 90 —— 100 —— 31°. 15′. —— Miles

We ſhall now give a Solution to a Traverſe of Ship and Port, in *Mercator's Sailing*.

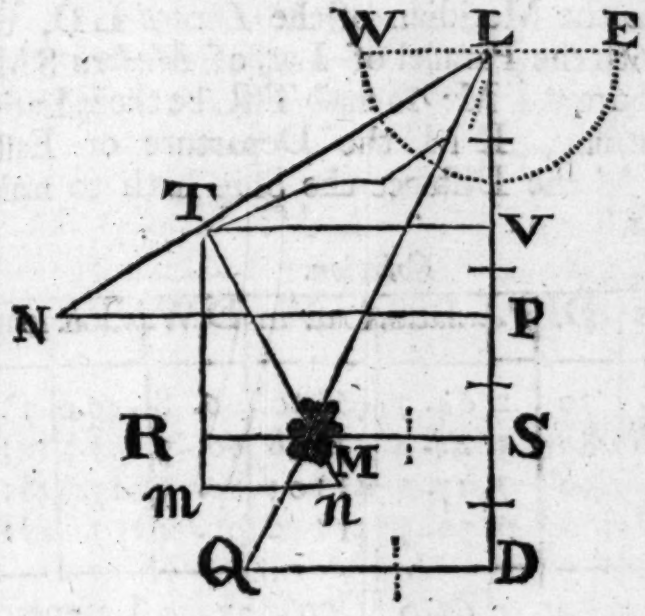
Mercator's Traverſe.

Prob. 13. Exam. 1.

ADMIT a Ship from the Latitude of (the Lizard) 49°. 55′. *and Longitude* 5°. 23′. W. *is bound to* Madera, *in Lat.* 32°. 25′. N°. *and Long.* 17°. 45′. W. *runs theſe Courſes*, viz. (1.) S. S. W 70 L. (2.) S. W. *by* W. 80 *Leagues*. (3.) W. *by* S. 90 L. (4.) W. S. W. 100 *Leagues*. *I demand the Bearings and Diſtance of the* Lizard *and* Madera, *and alſo the Courſe and Diſtance made; with the Latitude and Longitude the Ship is in; likewiſe the Bearings*

and

and Distance from the Lizard *and* Madera *to the Ship, at the End of her Traverse.*



Preparation.

	° ′		Mer.Pts.		° ′	
Lat.	49 : 55	N.	3467	long.	5 : 23	W.
	32 : 25	N.	2058		17 : 42	W.
	17 : 30		⅓)1409		12 : 19	
	20				20	
		M.*x*.Lat.	469-⅔			
x.Lat.	350 Lgs.				*x*. Long.	246 Lgs.

Course S. 27°. 38′. W. Dist. 395 Lgs. Departure 184 Leagues by Case 1.

2. With these given Things protract the *Mercator's* Triangle LDQ, by *Prob.* 4. *Case* 1. of this Sailing; so shall L. represent the *Lizard* and M. *Madera.*

3. Project your Traverse with the given Courses and Distances, as is directed in the first *Plain*

Sailing Traverſe foregoing; and the Ship will be found at the Point T.

4. Draw T R, the Meridian of the Ship, parallel to the Meridian of the *Lizard* L D, till it meet with the Parallel of Lat. of *Madera* S M, in R. and draw T M; ſo ſhall T R. be the *x.* Latitude or Southing, R M the Departure or Eaſting, and T M the Diſtance the Ship hath to make to *Madera.*

Solution.

Courſes	D.	P.	*x.* lat. S.	Lat. in	D. W.	*x.* lon.	long. in
S. S. W.	70	2	64. 7	46°. 10′.	26. 8	46.0	7°. 41′
S. W. b. W	80	5	44. 4	43 : 58	66. 5	91.3	14 : 14
W. b. S.	90	7	17. 6	43 : 04	88. 3	125.3	18 : 29
W. S. W.	100	6	38. 3	41 : 40	92. 4	157.0	25 : 13
	x. Lat.	165.0	Dep^{r}.	274. 0	Leagues		

I ſhall omit the Inveſtigations of the ſeveral Differences of Longitude in the Table above, for brevity ſake, and leave them to the diligent Learner. The *x.* Latitude is 165 Leagues, and then Dep^{r}. 274 Leagues the Ship hath made; therefore by the ſixth Caſe of *Plain Sailing*, Meth. 1. The Courſe will be found S. 59°. 00′. W. and the Diſt. 320 Leagues, Latitude the Ship is in, 41°. 40′. N°. and Longitude 25°. 13′. W. The *x.* Latitude in meridional Parts between 49°. 55′. Latitude is 237 Leagues, which ſet from L to P, and draw P N. (which is the whole *x.* Longitude the Ship hath made = 397 Leagues) parallel to T V, till it meet L T, produc'd in N. Again, the meridional *x.* Lat. between 41° 40′. Lat. in, and *Madera*'s Lat. 32. 25. is 232 Leagues, which ſet off from T to *m*, and draw the *x.* Longitude to *Madera m, n,* as before directed; ſo have you finiſhed the Scheme or Projection. Laſtly, To find

the

the Courſe (Bearings) Diſtance, and Eaſting the Ship muſt make to her intended Port *Madera*, by Caſe 1. *Mercator*'s Sailing foregoing: Thus,

		° ′	M.P.		° ′
Lat.	Ship	41 : 40	2755	long.	25 : 13 W.
	Mad.	32 : 25	2058		17 : 42 W.
		9 : 15	697		7 : 31 E
		20			20
			232 Lgs.		
x. Lat.		185 Lgs.	M. *x.* Lat.		150 Lgs. *x.* Long.

Then ſay,

As Mer. *x.* Lat. .. R. :: *x.* Long. .. T. Courſe.
—— 232 Lg. —— T. 45 —— 150 Lg —— S. 32°. 45′. E.

As S.C.C. .. *x.* Lat. :: R. .. Diſt.
— S. 57°. 15′. —— 185 —— S. 90 —— 219 Leagues.

As S.C.C. .. *x.* Lat. :: S. C. .. Dep^{r}.
— S. 57°. 15′. —— 185 —— S. 32°. 45′ — 119 Lgs E.

Ergo; *Madera* bares from the *Lizard* S. 27°: 38′. W. or near S.S.W. ½ W. Diſt. 395 Leagues; Weſting or Departure 184 Leagues.

The *Lizard* bears from the Ship N°. 59°. E. or Near N. E. by E. ¼ E^{t}. Diſt. 320 Leagues; Departure 274. Leagues E^{t}.

Madera bears from the Ship S. 32°. 45′. E^{t}, Diſt. 219 Lgs. Eaſting to *Madera* 119 Lgs. *Facit.*

Parallel Sailing.

PArallel Sailing is a Branch of *Mercator*'s Sailing, it is of Uſe in Sailing Eaſt or Weſt, or in the ſame Parallel of Lat. It's manifeſt from the Scheme in Page 34, that the Meridians incline from the Equinoctial nearer and nearer, till the Meet or Interſect in the Poles of the World N. and S, and conſequently the Degrees of Longitude

Longitude grow leſs and leſs, the nearer you approach the Pole. See the Scheme *p.* 87. in which P repreſents the Pole, PS Æ a Quadrant of the Meridian, Q Æ the Semidiameter of the Equator, and AS the Semidiameter of any Parallel of Latitude, which is to the Semidiameter of the Equator, as the Sine of the Arch P Æ, to the Sine of the Arch PS; that is, as the Radius is to the Sine Complemen of the Latitude.

Again, ſince the Circumferences of all Circles are as their Radius's directly, and that like Parts have the ſame Proportion with their Whole; it follows, that the Breadth of a Degree of Longitude in any Parallel of Latitude is to the Breadth of a Degree in the Equator, as the S. Comp. of that Lat. to the Radius; and conſequently as the Miles in the one to the Miles in the other.

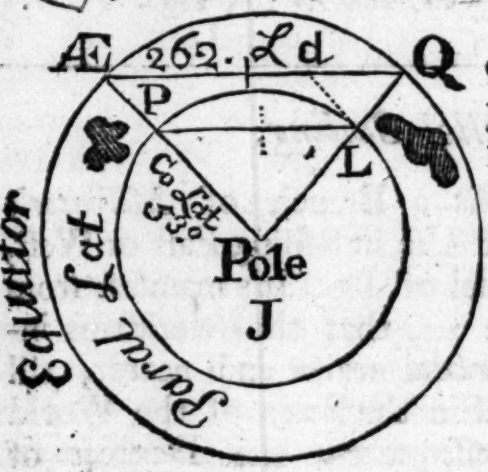
Prob. 14. *Caſe* 1.

Exam. 1. *Given x. Longitude between two Places in the ſame Parallel or Latitude, required their Diſtance. What is the Diſtance between Cape* St. Vincent *and* St. *Mary*'s?

Preparation.

	°	′				
From	23	40 W.	Long.	*St. Maria*	Lat.	37°. N.
Subt.	10	35 W.		*C. St. Vinc.*		

13 : 05 = 785^{m}. or 262 Lgs. the *x* Longit.



Explanation. The outward Circle repreſents the Equator the inward the Parallel of Lat. of 37°. *p* the Pole, *p* Æ = *p* Q Meridians (of S. *Mary*'s and St. *Vincent*) meeting in the Pole of the World. Æ Q. the *x*. Long. and PL the

the Diſt. between St. *Mary* and C. St. *Vincent*, Æ P the Lat. *p*. P the Comp. Lat. of both Places.

Conſtruction. 1. With a Sine of 90°. (= Chord of 60°.) deſcribe the Circle, Æ Q.

2. With the Sine of the Comp. Lat. 53°. (on the ſame Center *p*) deſcribe the Parallel of Lat. P L.

3. Draw the Lines P Æ for the Meridian of *St. Mary's*, and ſet off the *x*. Longitude 262 Lgs from Æ to Q, and from the Point Q to *p* draw the Line Q *p* for the Meridian of Cape St. *Vincent*; ſo ſhall L. be St. *Vincent*, and P. St. *Mary*'s.

Laſtly, Draw P L and it's the Diſt. required; and being meaſured on the ſame Scale of equal Parts, you took the *x*. Longitude Æ Q from gives 210 Leagues.

Demonſt. The Triangles, *p* Æ Q and *p* P L, are ſimilar and proportional by the parallel Lines Æ Q and P L, or by the equal Angles in each; therefore by *Euclid. Lib.* 6. *Prop.* 4.

1. As *p*. Æ .. Æ Q :: *p* P .. P L.
i. e. .. ℟ S. 90°. —*x*. Long. :: S. C. L. — Diſt.
2. As *p* P .. P L :: *p* Æ .. Æ Q.
i. e. S. C. Lat. — Diſt. :: ℟ S. 90°. .. *x*. Long.
3. As Æ Q .. Æ *p* :: P L .. *p* P.
i. e. As *x*. Long .. ℟ S. 90 :: Diſt .. S. C. Lat. *q. e. d.*

Therefore Solution *Logarithmetic*.

As ℟ .. *x*. Long. :: S. C. Lat. .. Diſt.
— S. 90 — 262 Lgs. —— S. 53°. —— 210 Leagues.

Inſtrumental by Gunter's *Scale*.

Obſerve in this and the following Caſes the general Rule, *p*. 110. Caſe 4. *Mercat. Sailing*.

This Caſe may be wrought by the Pen in all the Methods exhibited in *Plain Sailing*, Caſe 1. aſſuming the Comp. Lat. (the Courſe) and the *x*. Long. the Diſtance, to find the Departure, which will be equal here to the Diſtance in the Parallel.

Caſe 1.

Caſe 1. Exam. 2. *Two Ships* 100 *Leagues diſtant on the Equator; they both Sail* N°. *alike Diſt. till they come into the Lat. of* 60°. N°. *What is their Diſtance aſunder in that Latitude?*

Here is the ſame *Data*, as before, *i. e. x.* Longitude 100 Leagues, and parallel Latitude 60°, therefore project and work as before, *viz.*

As ℞ .. Long. :: S. C. Lat. .. Diſt.
—S. 90°—100 l.——30°.———50 Leagues.

Here you ſee the groſs Error of the *Plain Sailing*, in which the Ships will be as far aſunder in this Latitude, or even the Pole it ſelf as on the Equator, whereas you ſee by this Sailing, they are but half the Diſtance aſunder, and in the Latitude of 80°. they are but one tenth of the Diſtance aſunder, *viz.* in this Caſe but 10 Leagues, and if (poſſible) they ſail to the North Pole they muſt neceſſarily meet.

Corollary. Hence alſo is fouud how many Miles make a Degree of Longitude in any (Parallel of) Latitude; by which the Table following after the meridional Parts was made.

Caſe 1. Exam. 3. *If on the Equator* 60 *Miles makes a Degree of Longitude, how many Miles makes a Degree of Longitude in the Latitude of* 50?

As ℞ .. Equin. Deg. :: S. C. Lat. .. Paral. Deg.
—S. 90——60^{m}. ——— 40° ——— 38,57 Miles

By the Plain Scale; Thus

The given Latitude (as here 50°.) taken from the Line of Chords, and laid on the Line M. L. (Miles of Longitude) will give the Miles of a Degree of Longitude in that Latitude, in this Caſe 38,57. as before.

Now if you would turn Miles of Eaſting or Weſting into Degrees of Longitude, it's done by this Proportion; *Table* 15. As the tabular Miles

Miles, for the Latitude you ſail in to 1°. ſo is the Miles you have ſailed to the Degrees of Longitude; thus,

Suppoſe you ſail 150 Miles in the Latitude of 60. the tabular Miles is 30. Then,

As 30^m. .. 1°. :: 150^m. .. 5°. = 100 Lgs. and contrary; to convert Degrees of Longitude into Miles of Eaſting or Weſting. Say,

As 1°. .. 300^m. *x* Long. :: 30^m. P. M. .. 150^m. Eaſting or Weſting.

By the Help of this Table, may all the Caſes in this Sailing be reſolved, which I leave to exerciſe the Ingenuity of the young Student.

Prob. 15. Caſe 2. *Given, two Places in one Lat. and their Diſtance; required their x. Longitude. Suppoſe a Ship ſails Weſt* 210 *Leagues from Cape* St. *Vincent, What Longitude is ſhe come into?*

This is only the firſt Caſe inverted therefore having deſcribed the Equator with a Sign of 90°. and the Parallel of Latitude of C. St. *Vincent*, with the Sine of its Comp. 53°, alſo drawn the Meridian *p*. Q. Set off 210 Leagues from L to P. and draw the Meridian *p* Æ the Diſt. Line L P and the *x*. Long. Q Æ, which meaſur'd on the equal Parts is = 262 Leagues.

Logarithmetic.

As S. C. Lat. .. Diſt. :: R .. *x*. Long.
— S. 53°.——210——S. 90°.——262 Lgs.

	°	′	
To Long. Cape St. *Vincent* ——	10	35	W.
Add *x*. Long. 262 Leagues or——	13	05	W.
Sum is the Longitude the Ship is in =	23	40	W.

This Caſe may be alſo work'd by the Pen, in all the various Methods of *Plain Sailing* by Caſe 3. ſuppoſing the Courſe there as the comp. Lat. here, the

the Departure there as the Diſtance in the Parallel here, and the Diſtance found there ſhall be equal to the *x*. Longitude here.

Caſe 2. Exam. 2. *Two Iſlands (or Head Lands) are in the Latitude of* 70°. 10′. N°. *Diſt. aſunder* 250 *Leagues the Eaſtmoſt Iſland is in Long. of* 15°. 30′. W. *What Long. is the Weſtmoſt Iſland in? Project, and Work as before directed. Saying,*

As S. C. Lat. .. Diſt^{s} :: R .. *x*. Long.
— S. 19°. 50′.—250 l.—S. 90—737 Lgs. or 36°. 17′.

	°	′	
Then to the Long. of the eaſtern Iſle	15	30	W.
Add the *x*. Longitude	36	17	W.
Sum is the Long. of the Weſtern Iſle	51	47	W.

Caſe 2. Exam. 3. *Two Ships are in one Latitude of* 40°. N°. *Diſt. aſunder* 300 *Leagues; they both ſail South the ſame Diſtance, till they come under the Equinoctial; I demand their Diſtance aſunder there? and if the eaſtermoſt Ship, be in the Long. of* 20°. 15′. W. *the Sun being on her Meridian. What Longitude and Hour of the Day hath the weſtermoſt Ship?*

The *x* Longitude or Diſtance between the Ships on the Equator, is 392 Leagues, or 19°. 36′. found as in the laſt Example.

	°	′	
Then to the Longitude	20	15	W.
Add *x*. Longitude	19	36	W.
Longitude Weſtern Ship	39	51	W.

Now ſince Longitude and Time are both reckoned on the Equinoctial, and that every 15°. of the Sun's Diurnal Motion in the Heavens is equal to one Hour of Time on Earth; therefore divide the

the *x.* Longitude between the Ships by 15, (as below) and the Quote gives the Difference of Time between them: Thus,

5)19°: 36′
3)3 : 55 : 12″
1 : 18 : 24″

Divide by the Ratio of 15, *i. e.* 5 and 3, the Quote is 1 Hour, 18 Min. 24 seconds of Time, which subtr. from 12 Hours, remains 10ʰ. 41′. 36″. the Hour of the Day by the Westermost Ship, when it is Noon by the Eastermost.

Prob. 16. Case 3. *Given x. Longitude and Distance of two Places in the same Lat. required the Lat. Suppose two Islands are distant asunder* 210 *Leagues* E. *and* W. *and the x. Longitude between them is* 262 *Leagues; I demand what Latitude they are in?*

For the Projection, see the Scheme to the first Case of this Sailing; wherein, having described the Equator with a Sine of 90°. set off the *x.* Longitude 262 Leagues, and draw the Meridians of the Islands *p* Æ and *p* Q.

2. Set off the Distance 210 Leagues or = Parts from Æ to *d*, and from the Point *d* draw *d* L parallel to the Meridian *p* Æ, to cut the other Meridian *p* Q in L.

Lastly, with the Dist. *p* L, one Foot in *p*. sweep the Parallel of Latitude, and draw the Distance P L, which shall be equal to Æ *d*, and *p* P = *p* L, the Comp. of the Latitude required which is measur'd on the Line of Sines.

Logarithmetically.

As *x.* Long. . . R :: Dist. .. S. C. Lat.
— 262 Lgs. — S. 90 — — 210 Lgs — — 53°. which subtr. from 90 gives the Lat. of the Islands 37°. N°. if they are situated in the Northern Hemisphere.

Case 3.

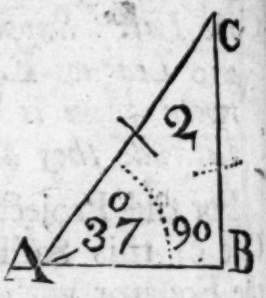
Caſe 3. Exam. 2. *Two Ships on the Equator, 400 Miles from one another, both ſail directly North alike Diſt. till they are 150 Miles aſunder; what Latitude are they in?*

By the Logarithms

As *x.* Long . . R :: Diſt. . . S. C. Lat.
——400^{m}.——S.90°.——150^{m}—67°.59′. requir'd.

There are other Varieties in this Sailing; as of two or more Ships, or Places in different Latitudes, which I forbear to mention, becauſe theſe are ſufficient for the Navigator's Uſe; however for the ſake of the Curious, I ſhall exhibit Variety of *Projections* in *Parallel Sailing* beſides the foregoing.

Examp. Let the Parallel Lat. be 37°. N°. and the *x.* Long. 262 Leagues, as in the firſt Caſe of this Sailing.



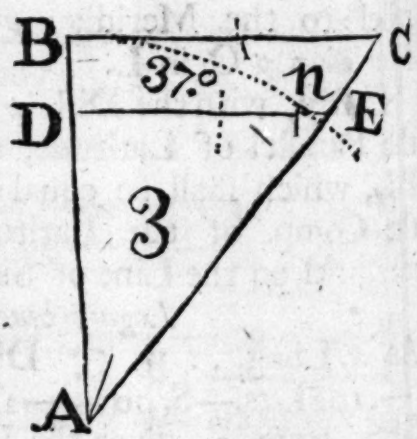
Projection. 2. By Plain Triangle with the Comp. Lat. 53°. and *x.* Long. 262 Leagues, project the Triangle ABC as directed in Caſe 1. Meth. 1. of *Plain Sailing*; ſo ſhall the Perpendicular BC, be the Diſtance in the Parallel requir'd.

Projection 3.

1. Make A B = Chord 60°. and erect the Perpendicular BC equal to the *x.* Longitude and draw C A.

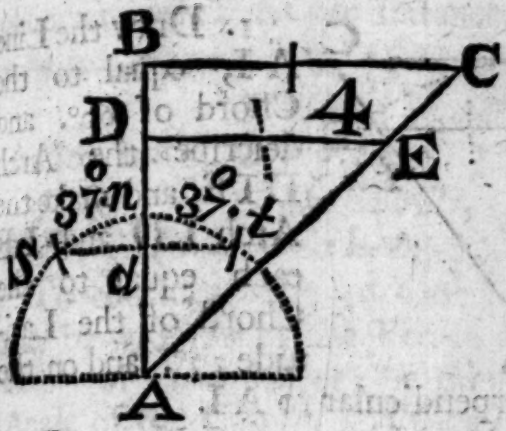
2. Set the Latitude 37°. on the Arch of 60° from B to *n*.

3. From the Point *n* draw DE Parallel to the *x.* Long. BC, to cut A C in E, ſo ſhall DE be the Diſtance required.



Pro-

Projection 4.



1. Make A *n* = Chord of 60°. and *n* B = the Double thereof.

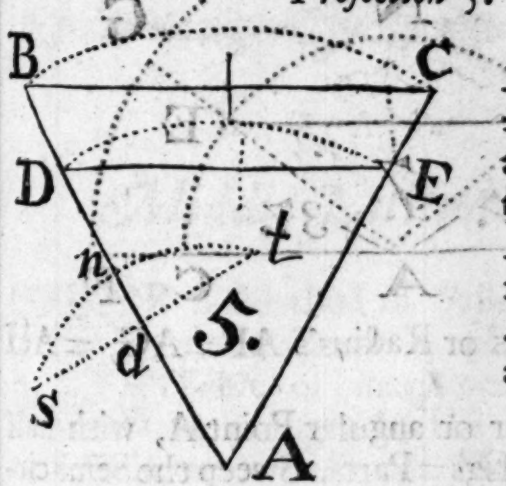
2. Erect the Perpend. B C which make = the *x*. Longitude (262) (as B C) and draw the Line C A.

3. Set off the Chord of the Lat. 37°. upon the Arch, or ſweep off 60° both Ways from *n* to S and *t*, and draw the Chord Line S *t*, to cut the Line A B in *d*.

4. Make *d* D = A *d*. or A D = the Double of A D.

Laſtly, From the Point D draw a Line Parallel to B C to cut A C in E; ſo ſhall the ſaid Line D E be equal to the Diſtance ſought.

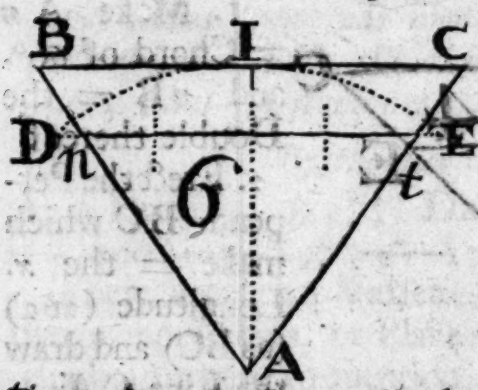
Projection 5.



1. Draw the Line A B, and make A *n* = Chord of 60°. and A B = double thereof, ſweep the Arch B C, which make equal to the *x*. Longitude 262, and draw the Line B C and C A.

2. Deſcribe the Arch of 60°. and on it both Ways from *n*, ſet off the Chord of the Lat. 37°. and draw the Chord Line S *t*, and make A D equal to the double of A *d* (as in the laſt Projection,) ſweep an Arch from D to E, and draw D E, which is the Diſtance required.

Projection 6.



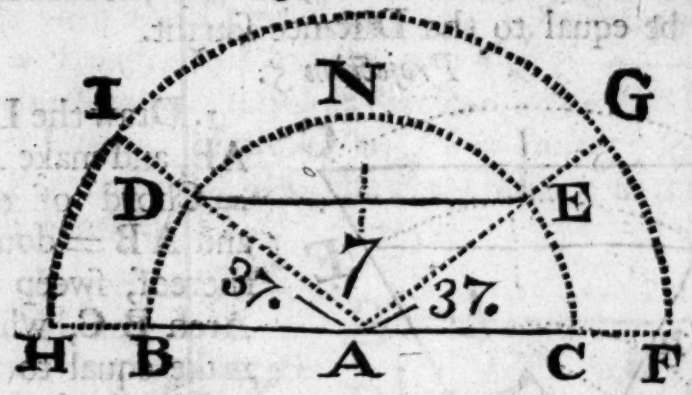
1. Draw the Line A I, equal to the Chord of 66°. and describe the Arch D I E, and make the Arch I D and I E each equal to the Chord of the Latitude 37°. and on the Point I erect a Perpendicular to A I.

2. Set off half the *x*. Long. 131 Leagues=Parts both Ways from I to B and C, and draw the Lines B A and C A.

Lastly, Draw the Chord Line D E, so shall it be the Dist. sought.

Projection 7.

1. Make the Angles G A F and H A I=37°.



and draw the Lines or Radius's A F=A G, =A H =A I.

2. On the Center or angular Point A, with half the *x*. Long.=131 Lgs=Parts. Sweep the Semi-circle B N C, which cuts the former Radius's A G and A I in the Points D and E.

Lastly, draw the Line D E, which is the Dist. required.

We may also vary the Proportions in the second Projection, as is obvious to those that work, by making

making each Side the Radius in a Right angled plain Triangle: As for Inſtance, where it is

1. As R .. *x.* Long. AC :: S.C. Lat. ∠A .. Diſt. BC.

It may be Secondly

As Sec. Lat ∠C .. *x.* Long. :: R .. Diſt. AC.

Or Thirdly,

As Sec. C. Lat. ∠A .. *x* Long. :: T. Lat .. Diſt. AC.

To conclude, the 2d Caſe of *Parallel Sailing*, may be wrought by the Pen in all the Methods by Caſe 2. of *Plain Sailing*; by taking the Lat. for the Angle of the Courſe, and the Diſt. in the Parallel for the *x.* Lat. and then the Diſt. in *Plain Sailing* will be equal to the *x.* Long. required here.

Alſo in the third Caſe of *Parallel Sailing*, taking the *x.* Long. and Diſt. in the Parallel, for the Diſt. and *x.* Lat. to find the Courſe; which here is the Parallel Lat. it may be ſolv'd by Caſe 4. *Plain Sailing*, according to the ſeveral Methods by the Pen only.

CHAP. IV.

Middle Latitude Sailing.

OR a Method of Sailing nearly agreeing with *Mercator*'s, performed without a Table of meridional Parts (and may be wrought by the Logarithms, *Gunter*'s Scale, or any of our Methods by the Pen in *Plain Sailing*.) Some ingenious Artiſts have obſerved, that this Sailing will ſerve without any conſiderable Error, in Runnings of 450 Miles, between the Equator and the parallel Lat. of 30 Degrees; of 300 Miles, between 30 and 60 Degrees, and of 150 Miles, as far as we have

any Occaſion; therefore ſufficiently exact to find the *x.* Long. in any 24 Hours run; and whoever was the firſt Author of this Sailing, he ought to be had in Eſteem for the Contrivance, which is thus: Having firſt taken an arithmetical Mean between the two Latitudes; that is, by adding the Lat. you ſail from to the Lat. you are in (or are bound to) half that Sum ſhall be the Mean or *Mid. Latitude*; then ſay by this Theorem or Proportion; As the S. Comp. Middle Lat. is to the Dep^{t}. (or Miles E. and W.) ſo is R$_{x}$ S. 90°. to the *x.* Long. required. Now if you change but the Name of S. Comp. Midd. Lat. to S. C. Parallel Lat. and of Dep^{t}. to Miles, of Diſt. Eaſt or Weſt in a Parallel, the Proportion is the ſame with the ſecond Caſe of *Parallel Sailing* foregoing. There are other Proportions in this Sailing, which we will ſhew a little farther.

I ſhall here propoſe the ſame Queſtion, as I did in the firſt Caſe of *Mercator*'s or Wright's *Sailing*, viz.

Caſe 1.

I demand the Courſe, Diſtance, and Departure (or Weſting) from the Lizard *to* Antegoa?

Preparation.

Lizard, *Antegoa*, } Lat. { 49°.55′.N°. / 17:15 N°. } Long. { 5°.23′W. / 61:44 W.

Sum 67:10

Sum or M. Lat. 33:35

90:00

Comp. Mid. Lat. 56:25

x. Long. 56:21

or = 1127 Lgs

Difference = 32:40 = 653 Lgs. *x.* Lat.

Pro

Projection. 1. Draw C L for a Meridian, or North and South Line; then as in the firſt Caſe of *Plain Sailing*, with the Comp. Midd. Lat. 56°. 52′. (as Courſe,) and *x.* Long. 1127 Lgs. (as Diſt.) project. the Triangle C S M.

2. C S. being continued, make S L equal to the *x.* Lat. 653 Leagues, and draw L M. the Rhumb-Line or Diſt. So ſhall L repreſent the *Lizard*, M. *Madera*, the Angle S L M the Courſe, L M the Diſt. and S M the Weſting from the *Lizard* to *Antegoa*; all which may be meaſured by the Chords and equal Parts, as I have ſufficiently exhibited in the foregoing Problems, to find which *Logarithmetic*, in the Triangle C S M, ∠ C. and C M to find S M. the Departure, as in Caſe 1. Meth. 1. *Plain Sailing.*

As R .. *x.* Long. :: S. C. Midd. Lat. .. Dep^{r}.
—S 90— 1127 l. —— S. 56°. 25′.——939 Lgs.

Then having the *x.* Lat. 653 Lgs. and the Dep^{r}. 939 Leagues, the Courſe and Diſt. may be found by by Caſe 6. of *Plain Sailing* Thus,

As *x.* Lat. .. R :: Dep^{r}. .. T. C.
—653 l.——T. 45°.——939 l.——S. 55°. 11′. W.
As S. C. .. Dep^{r}. :: R .. Diſt.
—S 55°. 11′.——939 l.——S. 90°.——1144 Lgs.

Here you ſee, this is but 43′. more Weſterly in the Courſe, 20 Leagues in the Diſt. 25 in the Dep^{r}. in above 1000 Lgs. run, which is about two Leagues in a Hundred too much; yet nearer to *Mercator*'s or the true Sailing by 188 Leagues in the Weſting, and 59 Leagues in the Diſtance run (of this Voyage, which is ſo much Weſterly) than *Plain Sailing*; but when your Courſe is more Southerly, as in a Voyage from the *Lizard* to *Port a Port*, *Lisbon*, *Cadiz*, the *Streights* Mouth, *Canary*, or *Cape de Verd* Iſlands; the Diff. between this Method and the *Mercatorian* will be very ſmall; and therefore much ſafer to truſt to than *Plain Sailing*.

The working the Proportions by *Gunter*'s Scale in this Sailing will be found very easy to the Learner, if he obſerves the general Rule in Page 110, *Caſe* 4 *Mercat. Sailing.*

Likewiſe this *Caſe* may be ſolved by the Pen only, in all the Methods propos'd; as in *Caſe* 1ſt and 6th of Plain Sailing; Arithmetical foregoing.

Caſe 2. *Given Latitudes and Courſe; required Diſtance, Departure, and x Longitude.*

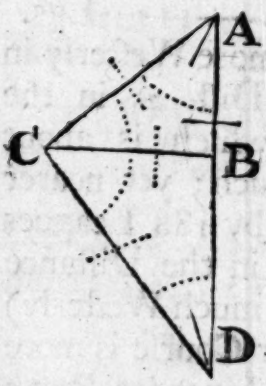
Sailing from the Lat. 48°: 50′ N. and Long. 7° 10′ W. S. W. by W. until by Obſervation the Ship is in Lat. 47°: 10′: N°. What is the Diſtance run Weſting and Long. arrrived in?

Preparation.

48°: 50′ Dep.
47 : 10 Obſervat.
1 : 40 = 100^{m} *x.* of } Lat.
48 : ½ Sum, or middle

7° 10′ W.
3 : 44 W. *x.*
10 : 54 W. } Long.

Projection 1. by Caſe 2. Plain Sailing conſtruct the Triangle A B C; with the Courſe S 56°: 15′ W and *x.* Lat. 100^{m} given.



2. make the Angle B C D, equal to the middle Lat. 48°: 00′ and draw the Line C D till it meet with the *x* Lat. A B produc'd in D. So ſhall D C be the *x* Long. and the Angle B D C, the S. Comp. of the middle Lat.

Operation by Logarith. the ſame as in Caſe 2, of Plain Sailing.

As S. C. C .. *x.* Lat. :: R .. Diſt. run
— S 33° : 45′ — 100^{m} — S. 90 — 178 Miles.

As

As S. C. C. .. *x* Lat. :: S. C .. Dep^t. Weſt.
S. 33°.45′ —— 100 —— S56°.15′ — 150 Miles.

Then find *x*. Long. as in Caſe 3. of Plain Sailing. You found the Diſtance *i. e.*

As S. C. mid. Lat : .. Dep. :: R *x* Long. Weſt.
—S. 42° : 00′ —— 150^m — S. 90 — 224 Miles,

Exactly agreeing with Caſe 2. *Mercat.* Sailing.

Caſe 3. *Given Lat. and Diſt. required Courſe, Depart. and x. Longitude.*

Sailing North-weſtward from Cape St. *Vincent* in *Portugal*, 300 Miles, until by Obſervation the Ship is found in the Latitude of 41° : 00′ N. What's the Courſe ſteer'd, Departure, and Longitude the Ship is in?

Preparation.

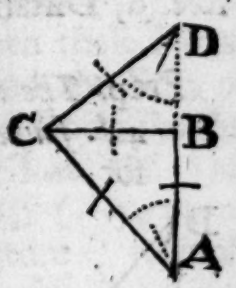
41° : 00′ — Obſerv'd
37 : 15 C. St. *Vincent*'s
3. 45 = 225 diff. of } Lat.
39 : 07 = ½ Sum or mid.

4° : 15 W.
10° : 35 W.
14 : 50 W. } Long.

Conſtruction.

1. Within the Diſt. 300^m and *x*. Lat. 225^m. make the Triangle A B C, by Caſe 4, *Plain Sailing*, continuing the Meridian A B at pleaſure.

2. Make, (as in the laſt Caſe) the Angle D C B = middle Lat. 39° : 7′. And draw C D for the *x* Long.



Logarithmetical, by the 3d and 4th Caſe of *Plain Sailing*:

As Diſt. R :: *x* Lat. .. S. C. Courſe.
—300^m— S. 90 —225^m: S. 48°: 35′ C. N. 41° 25′ W.

As R :: Dist. :: S. C. Departure
— S. 90 — 300^{m} — S. 41° : 52 — 198^{m} West.
As S C. mid. Lat. .. Dep. :: R .. x Long. W.
— S 50° 53′ — 198 — S. 90 — 255 Miles.

Or thus, by Prop. 1. of *Oppoſite Sides and Angles*, in Page 28, *Rule of Sines.*

As S. ∠ D .. Side A C :: S. ∠ A .. Side DC. *i. e.*
As S. C. mid. Lat. .. Diſt. :: S. Courſe .. x Long.
— S. 50° : 53′ — 300° — 41° : 25′ 255 m.

Or,

As T. C. mid. lat. .. Dep. :: S.C. mid. lat. .. x Long.
— T. — 50° : 53′ — 198 — Sec. 50° : 53′ — 255 ^{m}.

Note, The foregoing Caſe 2. may be work'd by the Pen, by all the Methods; as in Caſe 2. *Plain Sailing.* And this 3d, by the 4th and 3d of *Plain Sailing* Arithmetical. x Long. here is = 4° : 15′ W. which add to the Departed. Long. gives preſent Longitude.

Caſe 4. *Given Latitude and Depart. required Courſe, Diſt. and x Long.*

Sailing between the N. and E. from the Lat. of 45° : 00′ N. and Long. 14° : 50′. till I'm in the Lat. of 46° : 29 N. *per* Obſervation, and fifty Miles to the eaſtward, I demand the Courſe ſteer'd, Diſtance ſailed, and Longitude come into?

Prep. *The x. Lat. is* 89^{m}. *and middle Lat.* 45° : 44′. *found, as in the three laſt Caſes.* Then for

Projection.

1. With the x Lat. 89^{m}. and Dep. 59^{m}. Project the Triangle A B C, by the 6th Caſe of *Plain Sailing.*

2. Make the Angle B C D = middle Lat. 45° : 44°. and draw C D for the x Long. as before.

Opera-

Operation by Log's; as Caſes 6th and 3d of *Plain Sailing.* Meth. 1.

As ✕ Lat. .. R :: Departure T. Courſe.
— 98m. — T. 45° — 59m. — N°. 31d : 5′ Eaſt.
As S. C. .. Dep. :: R .. Diſt.
— 31° : 5′ — 59 — S. 90 — 114 Miles.
As S.C.mid. Lat.. Dep. :: R .. ✕ Long.
— S. 44° : 16′ — 59m S. 90 — .. 84m or 1° : 24′ E.
Then Long. 14 50′ -- ✕ Long. 1° : 24′ E. = 13° 26 W. the Long. the Ship is in.

To find the ✕ Long. (for any 24 hours run) by the Traverſe Tables. Having found the Comp. of the middle Lat. for the two Latitudes, (ſuppoſe of Yeſterday and to Day) which let be as in the following.

Examp. S. C middle, 44° : 16′. but 44° is the neareſt whole Degree, which is near enough; and Departure 59m. to find the ✕ Long.

Practice. Find the Comp. middle Lat. (44°) amongſt the Degrees, at the Top or Bottom of the Table, and under it, if you find it at Top, or above it, if you find it at Bottom) in the Column of Departure, find your Departure, and right againſt it, in the Right-hand Column (of ✕ Long.) is the ✕ Long. If you cannot find the Departure in the Column exactly agree with yours, break it into two Parts, and take out for both theſe Parts, at twice, under the ſame Degrees and the Sum of the two ✕ Longs. found will be the ✕ Long. ſought.

Examp. Let the Comp. middle Lat. and Departure be as above; and find 38,2 (— 59 = to) 20,8, in the Column of Departure; againſt which (in the Column of ✕ Long.) ſtands 55, and 30, which added together makes 85m. for the ✕. of Long. ſought.

This 4th Caſe of middle Lat. may alſo be wrought by the Pen, in all the Methods, by Caſe 6th and 3d of *Plain Sailing* Arithmetical.

Theſe

These four Cases are all that are useful in the Practice of keeping a Reckoning at Sea. As for the other Cases which are less useful, I shall only insert the *Data* and *Quæsita*, with the Canons or Proportions for finding what is requir'd, and leave the Operations for the Learner's Practice.

Case 5. *Given one Lat. Course and Dist. requir'd the other Lat. Dep. and x Long.*

1. For the x Lat.

As R .. Dist. :: S. C. C. .. x Lat.

2. For the Departure.

As R .. Dist :: S. C. .. Departure.

3. For the x. Long.

As S. C. midd. Lat. .. Dep. :: R .. x. Long.

Case 6. *One Lat. Course and Dep. given. Other Lat. Dist. and x Long. requir'd.*

1. For the x Lat.

As S. C. .. Dep. :: S. C. C. .. x Lat.

2. For the Dist.

As S. C. Dep. :: R .. Dist.

3. For the x Long.

As S. C. midd. Lat. .. Dep. :: R .. x Long.

Case 7. *Given one Lat. Dist. and Dep. required other Lat. Course, and x Long.*

1. For the Course.

As Dist. .. R :: Dep. .. S. Course.

2. For the x Lat.

As S. C. .. Dep. :: x. Lat. S. C. C. .. x. Lat.

3. For x. Long.

As S. C. midd. Lat. .. Dep. :: R .. x. Long.

Case 8. *Course, Dep. and x. Long. given. required both Latitudes and Distance.*

1. For the Distance.

As S. C. .. Dep. :: R .. Dist.

2. For

2. For the *x.* Lat.

As S. C. .. Dep. :: S. C. C. .. *x.* Lat.

3. For the middle Lat.

As *x.* Long... ℞ :: Dep.. S C. midd. Lat.

Then add ½ the *x.* Lat. to the middle Lat. (when found, as above) the Sum is the greater Lat. And ſubtracting the *x* Lat. from the middle Lat. the Remainder is the leſſer Latitude required.

Caſe 9. *Given middle Lat. Courſe and Diſt. to find both Latitudes, Depart. and x Long.*

1. For *x* Lat. and conſequently both Latitudes.

As Radius to Diſt. :: S. C. C. .. *x* Lat.

Then find both Latitudes; as in Caſe the 8th.

2. For the Departure.

As ℞ .. Diſt. :: S C .. Departure.

3. For the *x* Longitude.

As S. C. middle Lat. .. Dep. :: ℞ .. *x* Long.

Caſe 10. *Courſe, Diſt. and x. Long. given, to find both Latitudes and Departure.*

1. For the middle Latit.

As *x* Long. .. Diſt. :: S C. .. S. C. midd. Lat.

2. For *x.* Latitude.

As ℞ .. Diſt. :: S. C. C. .. *x* Lat.

Then find both Latitudes, as in Caſe 8th.

3. For the Departure.

As ℞ .. Diſt. :: S. C. .. Departure.

Caſe 11. *Given Courſe, x Lat. and x Long. to find both Latitudes, Diſt. and Departure.*

1. As for the middle Latitude.

As *x* Long.. . T. C. :: *x* Lat. .. S. C. midd. Lat.

By *x* Lat. and midd. Lat. find both Latitudes; as in Caſe 8th.

2. For

2. For the Distance.

As S. C. C. .. x Lat. :: R .. Dist.

3. For the Departure.

As S C C. .. x Lat. :: S. C. .. Departure.

Case 12. *Middle Lat. Course, and x Long. given, to find both Latitudes, Dist. and Departure.*

1. For x Lat.

As T. C. .. x Long. :: S. C. midd. Lat. .. x Lat.

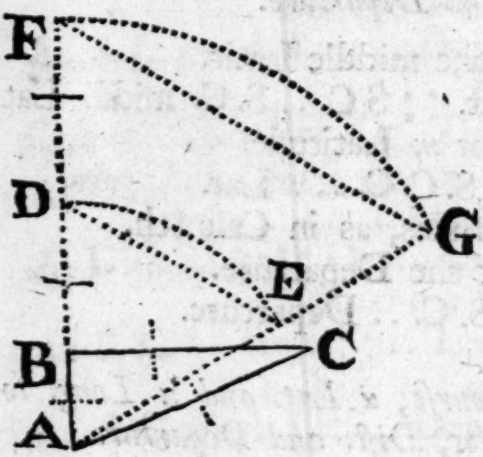
Then find Distance and Departure, as in Case 11.

Case 13. *Given one Lat. Departure, and x Long. Required the other Lat. Course and Dist.*

In this we shall give a Projection and Solution in Numbers.

Examp. Suppose a Ship sails between the North and East, from the Lat. of 48°: 50′ North, until her Easting be 150^{m}. and she hath differ'd her Long. 224^{m}. What Course hath she steer'd, and how far; and what Lat. is she arriv'd in?

Projection.



1. Make A F = the x Long. 224^{m}. A D = the Dep. 15^{0m}.

2. Make A G and and F G, each = the Sine of 90° and draw from the Point D, D E, parallel to F G, then shall A E be the Sine Comp. Lat. the Ship is in.

3. Make A B equal to the Lat. given; and this found, and B C, the Dep. required, equal to A D; and draw A C, and it's the Dist. run required.

Loga-

Logarithmetical.

As *x*. Lo. AF .. R. FG: : Dep. AD .. S. Co. L. AE.
— 224^{m}. — S. 90 — 150 — 42° : 03′

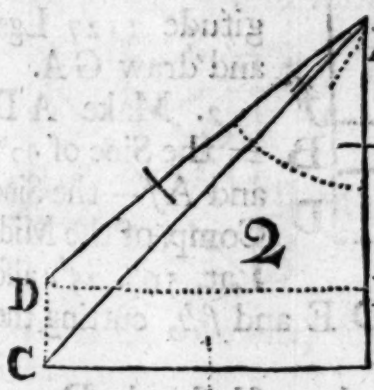
Whoſe Comp. to 90°. is 47′ : 57, the Lat. which taken from the Lat. departed from, remains 53^{m}. *x* Lat. Then by Caſe *Plain Sailing*,

As *x* Lat. .. R. : : Dep. .. T. Courſe.
— 53^{m}. — T. 45°. — 150^{m}. — N. 70° : 35′ Eaſt.
As S C. .. Dep. : : R .. Diſt.
S. 70° : 35′ — 150^{m}. — S 90°. — 159^{m}. —

Proceed we now to ſhew ſeveral other Varieties of Projections in middle Lat. Sailing, to oblige the curious Learner.

For *Examp.* Let the *x* Lat. be 653 Lgs. the *x* Long. 1127 Lgs. the middle Lat. 33° : 35′, and its Complement 56° : 25′ (as in the firſt Caſe of this Sailing) to find the reſt.

Projection 2.



1. Make A B = the *x* Lat. 653 Lgs.

2. Make the Angle D A E = S. Comp. middle Lat. 56° : 25′, and draw the Line A D, which make equal to the *x* Long. 1127 Lgs.

3. Let fall the Perpendicular D E, ſo ſhall D E be = the Departure.

4. Erect the Perpend. B C, which make equal to E D, and draw A C, the Diſtance run, and it's done.

Pro-

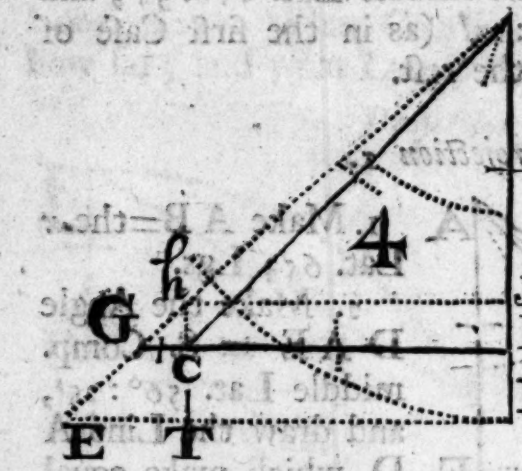
Projection 3.

1. Draw C B and make the Angle DCB = the middle Lat. 33°. 35′. and draw C D which make = the *x.* Long. 1127 Leagues.

2. From the Point D let fall the Perpendicular D B.

3. Produce B D and make B A = the *x.* Lat. 653 Leagues, and draw A C the Diſt. ſo ſhall the Angle BAC be the Courſe, and B C the Departure required.

Projection 4.



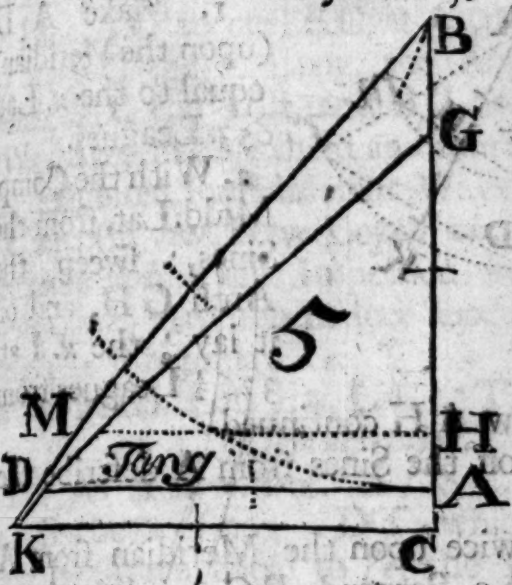
Make A B = the *x.* Lat. 653 Lgs. and erect the Perpend. B G which make = the *x* Longitude 1127 Lgs. and draw G A.

2. Make A D = the Sine of 90°. and A *f* — the Sine Comp. of the Mid. Lat. 56°. 25′. alſo erect the Perpendiculars D E and *f h*, cutting the Hipo. A G in *h*.

Laſtly, Make B C equal to *f h* for the Departure, and draw the Diſt. A C, ſo ſhall the Triangle be finiſhed.

Pro-

Projection 5.



1. Draw the Meridian O B, and from the Point A make (A O or) AB= the Sine of 90°.

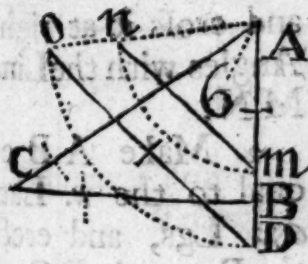
2. Make A G = the Comp. of the Midd. Lat. 56°. 25′ from the Sines.

3. Make B H and G C, each equal to the *x*. Lat. 653 Lgs. erect the Perpend. A D, and draw H M and C K parallel thereto.

4. Make C K = the *x*. Long. 1127 Leagues, and draw K G to cut H M in M.

Laſtly, Draw B M for the Diſt. then ſhall H M be the Dep^{t}. and the Tang. Line A D the Angle of the Courſe required.

Projection 6.



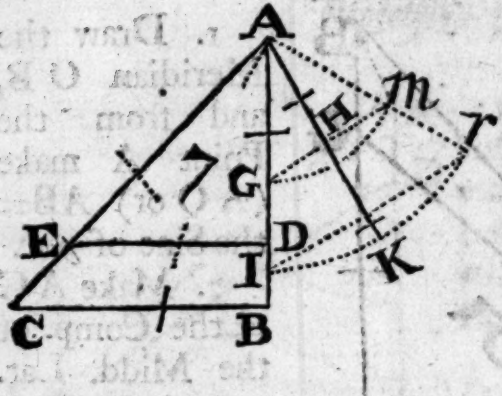
1. With 90°. of the Line of Sines deſcribe from A the Arch D O equal to 1127 Lgs.

2. Make A *m* = the S. Comp. Midd. Lat. 56°. 25′. (from the ſame Line of Sines) and deſcribe the Arch *m n*, then draw A O, and *m n*, ſo ſhall *m n* be the Weſting or Departure.

3. Make A B = the *x*. Lat. 653 Leagues, and erect the Perpend. B C equal to the Weſting *m n*, and draw A C which will be the Diſt. and the Angle B A C the Courſe required.

Pro-

Projection 7.



1. Make A D (upon the Meridian) equal to the *x*. Lat. 653 Leagues.

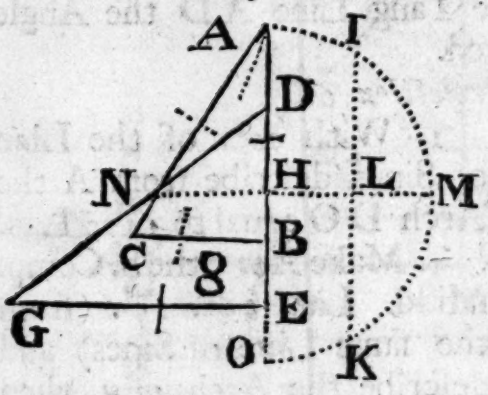
2. With the Comp. Midd. Lat. from the Sines, ſweep the Arch G H, and on it lay ½ the *x*. Lat. 326 ½ Leagues from G to H, and draw A H continued.

3. With 90°. off the Sines from A deſcribe the Arch I K.

4. Lay I K twice upon the Meridian from A to B, on B erect a Perpend. B C equal to the *x*. Long. 1127 Leagues, and draw the Line A C.

Laſtly, From D draw D E the Dep^r. Parallel to B C, ſo ſhall A E be the Diſt. and the Angle D A E, the Courſe required.

Projection 8. by Semicircle.



1. With a Chord of 60°. deſcribe the Semicircle A M O, and croſs it at right Angles with the Line M N.

2. Make A B equal to the *x*. Lat. 653 Lgs, and erect the Perpend. B C.

3. On the Semicircle A M O ſet off the Midd. Lat 33°. 35'. from M to I and from M to K, and draw the Chord Line I L K, and ſet off the Diſtance L M from A to D, and from B to E, and on E erect the Perpend. E G equal to the *x*. Long. 1127 Lgs, and draw G D, which cuts the Line M H produc'd in N.

Laſtly,

Laſtly, Through the Points A and N, draw the Line AC to cut BC in C; then is AB the *x.* Lat. EG the *x.* Long. the Angle BAC the Courſe, AC the Diſt. and BC the Dep^{r}.

We have, in *Caſe* third and fourth of this Sailing, exhibited four different Ways of finding the *x.* Long. (in any Days Logg) *viz.* 3 by the Logarithms, and 1 by Inſpection in the Traverſe Tables, we may alſo deduce another from Projection 4th foregoing, *i. e.*

As S.C. Midd. Lat. .. *x.* Lat. :: T. C. .. *x.* Long.

Demonſtration.

For, As AB. *x.* Lat. A*f* S.C. Midd. Lat. ſo is BG the *x.* Long .. DT, which by Conſtruction is always equal to *fe*, the Tangent of the Courſe, and by *Euclid.* 6. 4.

As AB .. A*f* :: BG *fh* (=DT.) the Tangent of the Courſe.

And ſo by inverting the Proportion, or Canon, any three Things being given, the fourth may be found by *Euclid. lib.* 5. *Prop.* 14 and 16. and *Corol.* always obſerving to make the required Term the fourth in the Proportion.

Oblique Sailing.

2. *Oblique Plain Sailing, or Oblique Angled Plain Triangles applied to Sailing.*

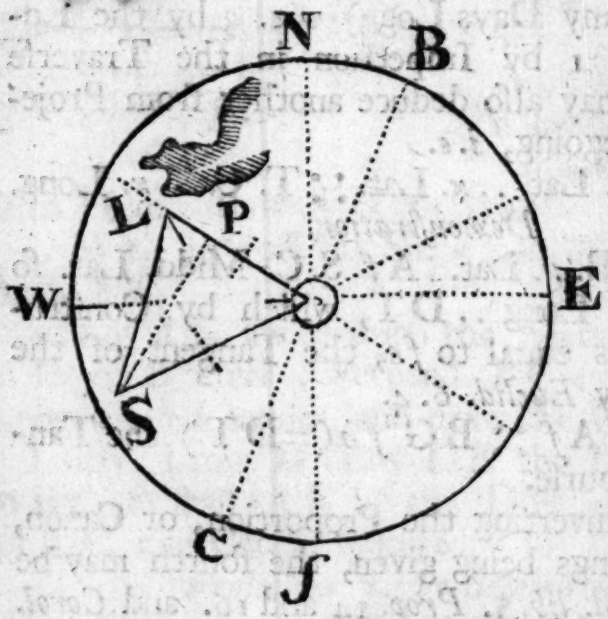
IN this Sailing I ſhall omit the ſeveral uſeleſs Queſtions that are generally propos'd, and inſert only ſuch as may be of Uſe to our young Navigator.

Caſe 1. Given the Angles, and a Side oppoſite to one of them, to find the other two Sides.

Exam. *Sailing along the* (Engliſh) *Shore* W.S.W. *I ſet a Head Land, by the Compaſs (ſuppoſe the* Li-

zard Point) *and find it to bear off my Ship,* N. W. *b.* W. *running (by the Log the ſame Courſe)* 25 *Miles, finds the ſaid Head Land to bear* N. *b.* E. *I demand how far this Head Land was from the Ship at firſt and laſt Setting of it?*

Conſtruction.



1. With a Chord of 60° deſcribe the Circle WNES, and by *Prob.* 2. of *Geom. Prob.* croſs it at right Angles, with the two Diameters WE and NS. So ſhall N repreſent the N°. S. the S°. W. the Weſt, and E the Eaſt.

2. Set off 5 Points from the Rhumbs or 56°. 15′. from the Chords, from N to L, and draw ⊙L a N. W. by W. Line.

3. Set off 6 Rhumbs=67°. 30′. on the Chords from ſ to S, and draw ⊙S the W. S. W. Line, which make equal to the Ship's Diſt. run, 25 Miles.

4. Lay off 1 Rhumb or Point = 11°. 15′. from N to B, and draw the N. by E. Line B C.

Laſtly from S draw SL parallel to B C, (by *Prob.* 5. *Geom.*) to cut ⊙L in L, and you have formed the Triangle ⊙SL, in which is given the Angle S⊙L, *viz.* from the N. W. by W. to W. S. W. 5 Points = 56°. 15′. and the Angle ⊙SL from N. by E. to E. N. E. which is 5 Points = 56°. 15′. alſo, and the Angle ⊙LS from the S. by W. to S. E. by E; that is 6 Points =

67°. 30′. likewiſe the Side ⊙S oppoſite to the Angle ⊙LS; to find the Sides ⊙L and SL, which are meaſur'd by a Scale of equal Parts, as has before been ſhewn. But to find them

Logarithmetic, by *Prop.* 1. *Elem. Trigonometry.*

As S∠L .. Side ⊙S :: S.∠S .. Side ⊙L

—S. 67°. 30′.—25^{m}.——S. 56°. 15′.——22^{m}.$\frac{5}{10}$.

And ſeeing in this Example the Angles ⊙ and S are equal, their oppoſite Sides LS and ⊙L, are alſo equal, *i. e.* ⊙L = SL; ſo that the *Lizard*, or Head Land, was from the Ship at firſt and ſecond Setting of it 22$\frac{1}{2}$ Miles.

As for the inſtrumental Operation, the Learner will be able to perform himſelf, if he obſerves what was ſaid in the Note following Caſe 4. *Mercator's Sailing*, without any further Inſtructions.

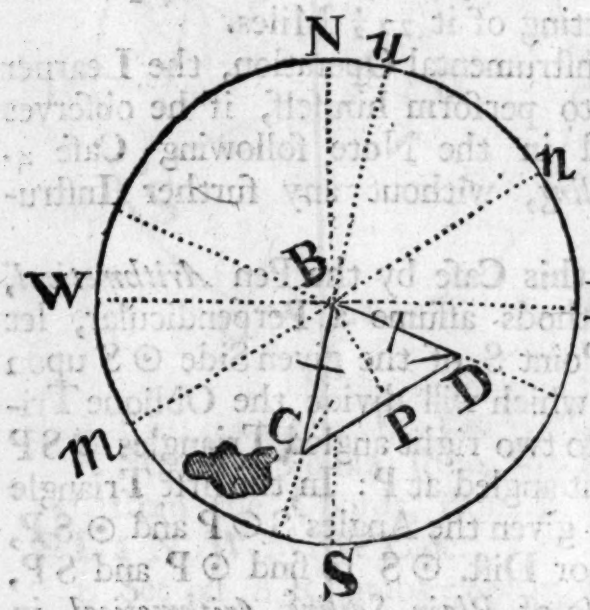
2. To ſolve this Caſe by the Pen *Arithmetical*, by all our Methods aſſume a Perpendicular, let fall from the Point S of the given Side ⊙S upon the Side ⊙L, which will divide the Oblique Triangle ⊙SL into two right angled Triangles ⊙SP and LPS, right angled at P: In the firſt Triangle ⊙SP, we have given the Angles S⊙P and ⊙SP, alſo the Hipo. or Diſt. ⊙S to find ⊙P and SP, by the firſt Caſe of *Plain Sailing Arithmetical*, in the ſecond Triangle SPL, we ſhall have then given the Angle PLS and Perpendicular SP. to find SL the Diſtance, and PL, by Caſe 2. *Plain Sailing Arithm.* then ⊙P + LP = ⊙L, the Diſt. of the Head Land from the Ship.

The Uſe of this Caſe is obvious; for as generally our Mariners judge or eſtimate the Diſtance of any Head Land from which they take their Departure to be ſo much or ſo much, this Caſe will eaſily ſolve it more true and *Mathematical.*

Case 2. *Two Sides and an oppoſite Angle given, to find the other Angles and Side.*

A Ship in the parallel Lat. of 46°. N°. (as at B) deſcries an Head Land (at C) diſtant from her 67 Miles, ſhe ſails E. S. E. 63 Miles (to D,) and then the Head Land (at C) bears S. W. by W. from her: How did the Head Land bear from the Ship, (when ſhe was at B,) and how far is it diſtant from her, (now ſhe's at D?

Projection.



1. Deſcribe the Circle W N E S and quarter it as in the laſt Caſe.

2. Set off 6 P = 67°. 30′. from S. and draw an ESE Line B D = the Ship's Diſt. ſailed 63^{m}.

3. Set off from S. towards W. 5 P = 56°. 15′. and draw a S. W. by W. and N. E. by E. Line *m* B *n*.

4. Draw from D a Line parallel to the ſaid Line *m* B *n*, as D C.

5. Then with 67^{m}. = Parts in your Compaſſes, and one Foot in B croſs the Line D C in C, and draw the Line B C, ſo ſhall C be the Head Land, and D C the Ship's Diſt. from it, and the Angle B C D = Arch *u n*, the Bearing of the Ship from it.

1. *Logarithmetical Prop.* 1. *Trigon.*

As Side B C. .. S. ∠D :: Side B D .. S. ∠C.
——67^{m}.——S. 56°. 15′.——63^{m}.——S. 51°. 26′.=
u n. N *n* = N.E. by E. 56°. 15′.—51°. 26′. = N *u*
4°. 49′, or B C; that is, the Head Land did bear from the Ship at first S. 4°. 49′. W. or near S. ½ W. then 56°. 15′. + 51°. 26′—180° = 72°. 19′. the ∠B.
As S. ∠D. .. Side B C :: S. ∠B. .. Side D C.
—S. 56°. 15′.——67^{m}.—S. 72°. 19′.——77 Miles, the Dist. of the Head Land from the Ship at the End of her Sailing.

2. *Arithmetical by the Pen.* Imagine (always a) Perpend. (B P,) let fall from the End of a given Side (D B,) opposite to a given Angle (D,) so shall there be given, the Dist. D B, 63^{m}. and ∠P D B 56°. 15′. in the right angled Triangle D P B, to find P D and P B by Case 1 *Plain Sailing*; then in the Triangle P B C. will be given B C 67^{m}. and P B, the Perpend. to find P C, and Angle P C B. by Case 4. *Plain Sailing Arithmetical*, and P D + P C = D C, the Dist. required; the Operation I leave to the Learner.

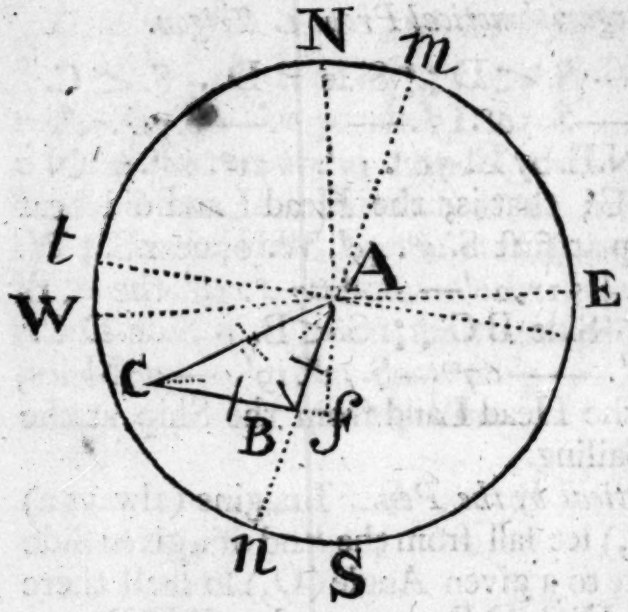
Case 3. *Two Sides with the Angle between them given; to find the other two Angles and third Side?*

A Ship sails S. S. W. 50 Miles, and then W. by N. 64 Miles, I demand the Course and Dist. from the first Place of Departure?

Projection.

1. the Circle described and quartered as in the first Case.

2. Set 2 P = 22°. 30′. of Chords from S to *n*, and draw A B = 50^{m}. Parts,



3. Set off 7 Points = 78°. 45′. of Chords, from N to *t* and draw A *t* a W. by N. Line and from B draw B C parallel to it, and make B C = 64^{m}. = Parts.

Laſtly, Draw the Line A C, and it's the Ship's Diſt. and the Angle B A C her direct Courſe from her firſt Place A. To find which *Logarithmetic*, by Caſe 2. Rule of *Tangents*, *Elem. P. Trigon.*

Preparation.

A C + A B = Z 114 } ∠B — Z 3 ∠^{s} 180 is
* 14 } 78°. 45′. its ½ = 39°. 22′. the half Sum of the unknown Angles A and C.

Logarithmetic.

As A C ± A B .. A C — A B :: T. ½ Z un. ∠^{s} .. T. ½ * ∠^{s}.
—— 114^{m} —— 14^{m} — T 39°: 22′ — T. 5°: 45′

Then 39°: 22′ ± 5°: 45′ = { 45°:: 07′ } grt. } ∠ { A
{ 33 .. 37 } leſs. } { C.

To the ∠A 45°: 07′ add Sn. S. S. W. = 22°: 30′, the Sum is S C. = 67°: 37′; that is the Courſe from the firſt Place. A is S. 67°: 37′ W. or near W. S. W.

The Diſt. A C is found as in Caſe 1. *viz.*
As S ∠A .. Side B C :: S ∠B .. Side A C.

S. 45°.

S. 45° : 07′ : 64^{m} { —S. 180° — 101° : 15 } — 88½ Mil.
{ Or S. 78 : 45 }

Note, When any Angle is greater than 90°, ſubtract it from 180, and the Reſidue take out of the Table of Sines, to work with as above.

2. By the Pen *Arithmetical*.

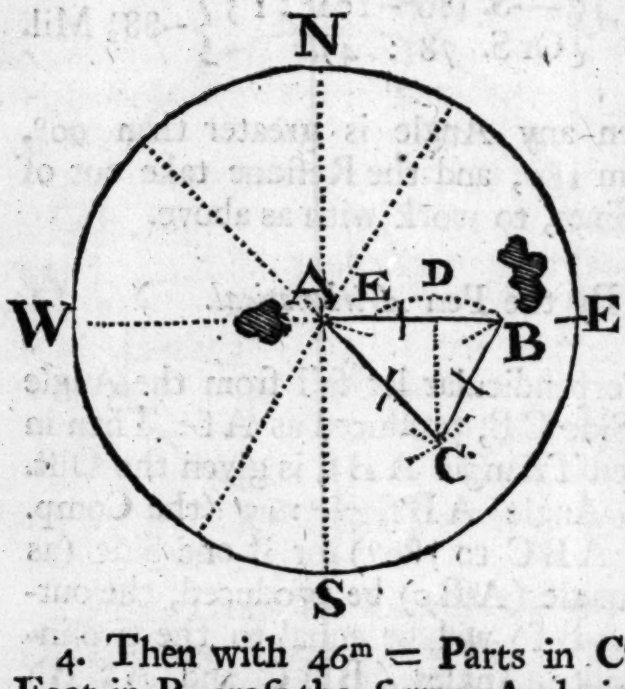
Aſſume a Perpendicular let fall from the Angle A, upon the Side CB, produced as Af: Then in the right-angled Triangle ABf, is given the Diſt. AB 50^{m}, and Angle ABf, 78° : 45′ (the Comp. of the Angle ABC to 180°) for if one Side (as CB) of a Triangle (ABc) be produced, the outward Angle (ABf) will be equal to the two inward and oppoſite Angles (BAC, and ACB) and all the three Angles (BAC, ACB, and ABC) ſhall be equal to two Right-angles, (or 180°) by the 32d of the firſt of *Euclid*.

To find the Side Af and fB, by Caſe 1. *Plain Sailing*: then CB + Bf, is = fc; in the Triangle Afc: Then you'll have given the Side A*f*, and Side *fe* to find AC the Diſtance, and Angle CA*f* by Caſe 6th of *Plain Sailing Arithmetical*.

Caſe 4. Admit two Ports in the ſame Lat. Diſt. aſunder 58^{m}. and a Ship ſails from the Weſtermoſt, between the South and Eaſt 65 Miles, and then ſhe is 46 Miles from the Eaſtermoſt Port; I demand the Courſe ſhe ſteered, and how the Eaſtermoſt Port bears from her?

In this 4th Caſe are given the three Sides; to find the Angles.

Projection.



1. the Circle deſcrib'd & quarter'd.

2. Set off 58^m = Parts from A to B, on the Eaſt and W. Line.

3. With 65^m = Parts in your Compaſſes, and 1 Foot in A, deſcribe an Arch at C.

4. Then with 46^m = Parts in Compaſſes, one Foot in B, croſs the former Arch in C. and draw AC, and BC.

5. From the Point C, let fall the Perpendicular CD, and it ſhall divide the Oblique Triangle ABC into two Right ones, ADC, and BDC.

6. Make DE = DB, ſo ſhall AD be the greater, DB, the leſſer Segment; or Part of the Baſe AB, and AE, the *x* of thoſe Segments; to find which Logarithmetical,

Prep. $AC \pm BC = \frac{Z}{X}$ Sides $\left\{\begin{matrix}111^m\\19^m\end{matrix}\right\}$ Then,

As Baſe AB.. Z Sides AC and BC :: X Sides, AC and BC.. X Segments of the Baſe AE; *i.e.*

As 58^m .. 111^m :: 19^m .. —— 36^m.

Then $AB\,58 \pm AE\,36 = \left\{\begin{matrix}94\\22\end{matrix}\right\}$ the $\frac{1}{2}$ of which is the Baſe $\begin{matrix}AD\\DB\end{matrix}\left\{\begin{matrix}47\\11\end{matrix}\right\}$

Then

Then by Caſe 5. *Plain Sailing.*

As AC .. R :: AD .. S. ∠ACD
— 65^m S. 90°. — 47^m. — S. 46° : 32′ Whoſe Comp. to 90°. is the ∠ A 43° : 28′, from the Eaſt: Therefore the Ship's Courſe was S. 46° : 32′ E.

As BC .. R :: BD .. S. ∠BCD.
— 46^m — S. 90 — 11^m — S. 13° : 15′. So that the Eaſtern Port bears N. 13° : 15′ E.

By the Pen and natural Arithmetick, in the *Rule of Three.*

As Sd. AB .. Z Sds :: x Sds .. x Sgt Baſe.
— 58 — 111 — 19 — 36^m AE.

Then proceed as before, to find the Baſes AD and DB.

AB 58 —
x Segt 36 —
Z 94
22
½ Z 47 = AD
½ x 11 = DB

The Angles ACD and BCD may be found by Caſe 5th of *Plain Sailing* Arithmetical.

Turning to Windward in Oblique Sailing.

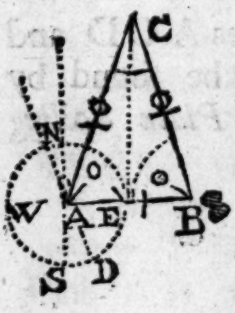
3. I Shall now give ſome few Queſtions in this Sailing, uſeful to gain a Port in the ſhorteſt Time, when the Wind is contrary or ſcant.

A Ship, ſailing to Windward, will uſually lie within 5 ½, or 6 Points from the Wind; but by reaſon of her Leeward-way, ſhe will ſcarce make her Way good (with her Top-ſails ſet) within 6 ½, or 7 Points from the Wind; ſometimes more, ſometimes leſs, according as the Sea is rougher

rougher or ſmoother, and according to the Mould of the Ship, and Sail ſhe bears: So that in ſailing to a Place directly to Wind, ſhe ſails uſually 3 or 4 times the Diſtance of that Place before ſhe arrives at it. But if the Place ſhe is bound to, be not directly to Windward, but within 1, 2, 3, 4, 5, or 6 Points of the Wind; then, tho' ſhe turn to Windward, as before, yet ſhe will ſooner arrive at the Place than before: But how, and in what Proportion for the one, and for the other, may appear by theſe enſuing Problems, *viz.*

Prob. 1. The Wind Eaſt, and a Ship bound to an Iſland 80 Miles directly to Windward, making her Way good (when Variation Lee-way allow'd) within 6 Points, or 67°: 30′ of the Wind;

I demand her Diſtance upon each Tack to gain that Iſland?



Projection.

1. The Circle being deſcrib'd and and quarter'd as before, ſet off 80^{m}. from the Center A to the Port, and draw A B, the Diſt. of the Port.

2. Set off 6 Rhumbs, 67°:30′ from E, the Eaſt Point, both Ways, toward the North and South, and draw Rhumb-Lines through theſe Points, as A C and A D, (ſhewing how the Ship will lie on each Tack).

3. From the Point B, draw B C parallel to A D, to cut A C in C, the Point where the Ship tacks. A C is the Star-board Tack, and C B the Lar-board, the Diſtance on each being equal, becauſe the oppoſite Angles B and C are equal. Or without the Circle you may project it thus; Make A B = 80^{m} pts. and the Angles B A C and A B C = each to 67° : ½ and draw A C and B C to interſect each other in C, the Place where the Ship goes about.

Loga-

Logarithmetical, by *Caſe* 1. *Ob. Sailing.*

Prep. $\angle B + \angle A = 135°$ and $180° - 135° = 45°. \angle C$.

— As S$\angle$C. S^{d}. AB :: S^{n}. $\angle$A. Side BC = AC.

——S. 45° — 80^{m} —— S. 67° : 30′ — 104^{m} $\frac{1}{2}$ on each Tack.

Prob. 2. The Wind at Eaſt, and a Ship plying to Windward, having run 209 Lgs. that is, 104^{m} $\frac{1}{2}$ with her Star-board Tack, and 104^{m} $\frac{1}{2}$ with her Lar-board Tack on Board, is arrived at a Port 80 Leagues directly to Windward;

I demand how near the Wind ſhe makes her Way good?

Project. See the laſt Scheme.

1. Make AB = 80 Lgs. and the Sides AC, and BC, each = 104 $\frac{1}{2}$ (as in *Caſe* 4th *Ob. Sailing* foregoing) and draw AC, and BC.

2. Let fall a Perpend. CE, from C, on AB, and 'twill divide the Baſe AB, equally in E, and the *Oblique* into two equal right-angled Triangles, AGE, and BCE; in each of which we have given AC, or BC 104^{m} $\frac{1}{2}$ and $\frac{1}{2}$ AB = 40^{m} to find the Angles at A or B, by *Caſe* 5th, *Plain Sailing.*

Therefore by *Logarithms*;

As S^{d}. AC .. R :: S^{d}. AE .. S. C. $\angle$CAE.

— 104^{m}.5 S. 90 —— 40^{m} —— S. $\angle$ACE 22° : 30′

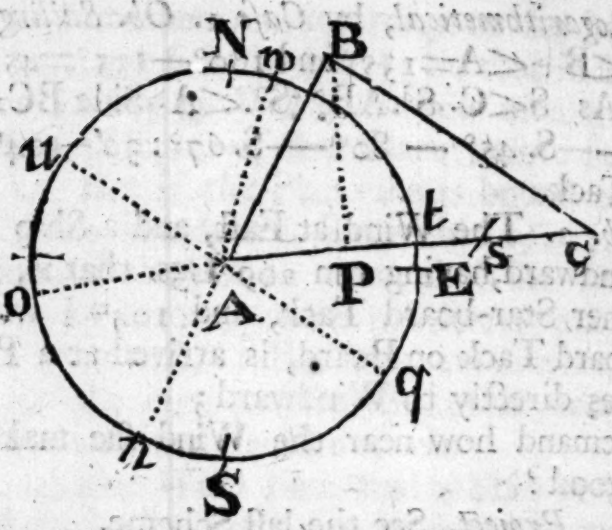
the Comp. to 90°. is 67° : 30′. or 6 Points from the Wind. ſhe made her Way. Therefore,

Courſe on the $\left\{\begin{matrix}\text{Star-board}\\ \text{Lar-board}\end{matrix}\right\}$ Tack $\left\{\begin{matrix}\text{N. N. E.}\\ \text{S. S. E.}\end{matrix}\right.$

Prob. 3. Admit a Ship is bound to a Port that lies N. N. E, $\frac{1}{2}$ E. diſtant 108 Leagues, the Wind being at N. by E. and ſhe can lie no nearer the Wind than 6 Points, I demand her Diſtance upon each Tack, to gain the ſaid Port?

Projection. The Circle being drawn and quarter'd as formerly, ſet off two Points from the N°. toward the Eaſt, and draw the Wind-Line A. *w.*

2. Set



2. Set off 6 Points = 67 : 30′ on each Side the Wind-line to *u* and *t*, and draw A *u* and A *t*.

3. Set off the Diſt. of the Port 108 Leagues from A to B, on the N. N. E. Line A B, and through B draw B C parallel to *u* A, till it meets A *t* produc'd in C, then will A C and E D be the Diſtance on each Tack required.

It's evident here, the Ship lies up with her Lar-board Tack E. by N. and on her Star-board Tack N. W. by W. therefore, from the N. N. E. to E. by N. is 5 Points = 56° : 15′ ∠ B A C, from C A *o*, a W by S. Line to A *u* (Parallel to B C, a N. W. by W. Line, is 4 Points = 45° = ∠ A C B, B A *n*, is a W. S. W. Line, and B C (Parallel to A *q*, is a S. E. by E. Line from the S. S. W. to S E by E. is 7 Points = 78° : 45′ = ∠ A B C. So have you given all the Angles A, B, and C. *&c.* and oppoſite Side A B, to find the other Sides A C, and C B. by Caſe 1. *Oblique Sailing.*

Logarithmetical.

As S. ∠ C. 45° .. S^{d} AB 108^{m} : : S ∠ B 78° 45′ .. S^{d} A C 149,8 Leagues Diſt. on Larb^{d} Tack

As S ∠ C 45° .. Side AB 108^{m} : : S ∠ A. 56° : 15′ . S^{d} B C 127 Leagues, Diſt. on Star-board Tack, to gain the deſired Port.

Prob. 4.

Prob. 4. The Wind at N. by E. admit two Parts lie N. N. E. and S. S. W. distant 108 Leag^{s}. A Ship sails from the Southermost close haul'd upon the Wind, 149,8 Leagues, with her Lar-board Tack; and 127 Leagues with her Star-board Tack a-board, then arrives at the Norther-most Port; I demand how near the Wind she makes her Way good upon each Tack?

Projection. 1. The Circle describ'd, and the Wind-line set off, as in the last, *Prob.* 2. draw a N. N. E Line, and make A B on it = 108 Leagues (the Distance of the Ports). Make A C = 149,8 Leagues, and B C = 127 Leagues, and let fall the Perpend. B P, and make P S equal to P A, so shall C *s* be the *x* Segments of the Base A C, as in the 4th Case of *Oblique Sailing*.

Logarithmetical. Vid. last *Prob.*

Prep. A B + B C = 235 and B C — A B 19.

Then,

As A C .. A B + B C :: B C — A B .. E P — P A;

i.e. — 149,8 — 235 — 19 — 29,8 Or,

As Base .. Z S^{ds} :: *x* Sides .. *x* Seg. Base S C.

Then A C 149,8 $\frac{+}{-}$ S C 29,8 = $\begin{cases} 89,8 \\ 60 \end{cases}$ $\begin{cases} 2\,C\,P \\ 2\,A\,P \end{cases}$ $\begin{cases} 89,8 \\ 60. \end{cases}$

As A B .. R :: A P .. S. ∠ A B P.

— 108^{m} — S 90° — 60^{m} — 33° : 45′ Comp. is

— 56° : 15′ ∠ B A C. that is, 5 Points from N. N. E. or 6 Points from N. by E. she lay up with her Lar-board Tack.

Of Currents.

4. *Currents* are certain Settings of the Stream, at Sea (or of the Tide in a River) by the means of which, all Bodies, (as Ships or Boats) mov'd therein, are compell'd to alter their Course, and submit to the Motion impress'd upon them by it. Thus, in the following Scheme.

If a Body (or Ship) be agitated by two Motions at the ſame Time, the one with a certain Velocity (or Swiftneſs) that will carry her according to the Direction of the Line A B, the Length of A B in a certain Time; the other according to the Direction of the Line A D, with a Velocity that will carry her to the Diſt. A D, in the ſame Time. I ſay, that the Body (or Ship) will deſcribe the Diagonal Line A C; and at the end of that Time will be found in the Point C.

From which it is plain, that when a Ship ſails in a Current, her Motion is compounded of two Motions, *viz.* The apparent Motion of the Ship, which is known by the Compaſs, Log, *&c.* And the Motion of the Current. The approved Method to find which, (as I have often practis'd in *Weſt-India* Voyages, *&c.*) is thus;

When there is a ſmooth Sea, and not much Wind, hoiſt out your Boat, and take into her three or four Men, with a Compaſs, a Log-line, and a large Log, and half-minute Glaſs; alſo a Quoil or two of Inch Rope, (when you are a little from the Ship) which faſten to the Bayle of a large Kettle, or great Iron Pot; caſt over-board the Kettle, letting it ſink at leaſt 80, or 100, or 120 Fathom, (the more the better); then belaying the Rope about the Boat's Stem, it will bring her up, and make her ride as if at Anchor; then heave your Log, and turn up your half-minute Glaſs (as you do in the Ship, to find her Diſtance run) and as you veer out the Log-line, ſet the Driſt of the Log by your Compaſs, ſo ſhall you know if there be any Current or not, and if any, how it ſets, and the Rate of driving: As ſuppoſe you find the Current ſets Eaſt 1 ½ Knot in ½ Minute, then is the Motion of the Current Eaſt, 36 Miles in 24 Hours:

Hours: But you muſt obſerve, 1. To allow the Variation of the Compaſs (by the Rules hereafter given.

2. If the Rope be 80 Fathom allow $\frac{1}{4}$ Part; if 100 Fathom $\frac{1}{3}$ Part, &c. of the Drift of the Current more for the Drift of the Boat; for though the Boat ſeem to ride or lie ſtill, yet ſhe is found by Experience to drive at the ſame Time.

Having, by this Experiment, found the Quality and Quantity of the Current, the Ship's true Motion may be obtained by the following Problems.

1. If a Current ſet with the Courſe of the Ship, it augments her Velocity or Motion, by as much as is the Drift or Rate of driving of the Current.

Example. Thus if a Ship ſail S. S. W. 45^{m}. in 24 Hours; and a A Current ſets S. S. W. 36 Miles in the ſame Time, her Courſe is S. S. W. 60 Miles: For 24^{m}. more 36^{m}. is equal to 60^{m}.

2. If a Current ſet againſt the Ship, it leſſens her Velocity or Diſt. apparent) by juſt ſo much as is the Current's Drift.

Thus if a Ship ſail S. W. 110^{m}. in a Current that ſets N E 24^{m}. in the ſame Time, then her true Courſe will be S. W. 76 Miles; for 110^{m}. leſs 24^{m}. is equal to 76 Miles.

Prob. 3. If the Ship thwart the Current, it not only leſſens or augments her Velocity, but gives her a new Motion, compounded of that of the Ship and Current, (as is manifeſt in the preceding Scheme) which if not allow'd for in your Reckoning, you can never certainly, keep a true Journal, or know the Place of your Ship; therefore,

Caſe 1. Given Courſe and Motion of the Current, and Courſe and Diſt. ſailed, to find the Courſe and Diſt. made good?

Exam.

Exam. 1. Suppoſe a Ship ſails S°. 50^{m}. in 24 Hours in a Current ſetting E. (that is on the Beam or Broad-ſide, as the Sea Phraſe is) 36^{m}. what is the Ship's true Courſe and Diſt. run?

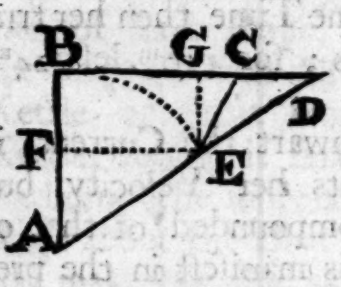
Conſtruction. In the foregoing Projection ABCD. Let AD=50^{m}. be the Ship's Courſe and Diſt. (which we may call her ſimple Motion) DC=36^{m}. the Current's Motion, AC the Line of the Ship's true Motion or Diſt. and the Angle DAC the Ship's true Courſe.

Then, *Logarithmetical* by *Caſe* 6. *Plain Sailing.*

As Simp. Mot. .. R :: Cur. Mot. T. Ship. tr. Courſe.
—AD. 50^{m}.—T. 45°.—DC 36^{m}.—∠DAC 35°. 45′. the Ship's Courſe made good, is S. 35°. 45′. E.

As S. tru. C. .. Cur. Mot. :: R .. Diſt.
—S. 35°. 45′.——36^{m}.——S. 90°.——61 Miles

Exam. 2. A Current ſetting abaft the Beam or Quarter, or before the Beam or Bow; ſuppoſe a Ship ſails N.E 100^{m}. in a Day, and a Current that ſets E 30^{m}. in the ſame Time, I demand the Courſe and Diſt. made good?



Projection Geometrical.

1. Draw AB, and project the Triangle ABC with the Courſe NE=45°. and Diſt. 100^{m}. as in Caſe 1 of *Plain Sailing.*

2. Set off the Current's Motion 30 Miles from C to D, and draw the Ship's true Diſt. AD; then is C the Place of the Ship without, and D her Place with Allowance for the Current. Then

Logarithmet. by *Caſe* 1. *Plain Sailing.*

As R .. Diſt. :: S. C. .. Dep^{t}.
—S. 90°.——100——S. 45°.——71^{m}.

Then

Then $71^m. + 30^m. = BD$ / $BC + CD$ } $101^m.$ true Dep^r.

And the *x.* Lat. A B is alſo $71^m.$ becauſe the Courſe is N E, or an Angle of $45°.$ therefore by

Caſe 6. Plain Sailing.

As *x.* Lat. .. R :: Dep^r. .. T. tr. Courſe.
— $71^m.$ — T. $45°$ — 101^m — N°. $54°. 54'.$ E.
As S. C. $54°. 54'.$ .. Dep^r. $101^m.$ R .. Diſt. $123^m.$ the Ship hath made good.

If the Current ſets upon an oblique Courſe, and not due Eaſt, Weſt, North, or South, the Operation will be as follows:

Exam. 3. Admit a Ship in 24 Hours ſails N. E. $100^m.$ in a Current that ſets S. S. W. $30^m.$ in the ſame Time; What is her Courſe and Diſt. made good?

Projection.

1. Conſtruct the Triangle A B C as in the foregoing Queſtion, with the Courſe N. E. Diſt. $100^m.$

2. Make C E a S. S. W. Line $= 30^m.$ that is, C A being a S. W. Line $= 45°.$ and S. S. W is $= 22°. 30'.$ therefore $45°. - 22°. \frac{1}{2} = 22°. \frac{1}{2}.$ Make the Angle A C E $22°. 30'.$ and draw C E which make $= 30^m.$ draw alſo A E, and E F parallel to B C, alſo E G Parallel to A B, ſo ſhall the Angle E A F be the Ship's true Courſe, and A E her Diſt. made good.

By the laſt Queſtion, the *x.* Latitude A B was found to be $71^m.$

Then (the Angle C E G is $= 22°. 30'$, and the Diſt. E C $30^m.$ becauſe E G is a Meridian, and E C a N. N. E. Line; therefore by the Logarithms, Caſe 1. P. S.

As R S. $90°$ .. E C. $30^m.$ :: S. $\angle$ C E G $22°. \frac{1}{2}$ .. G C $11^m.5$
As R S. $90°$ .. E C. $30^m.$ :: S. $\angle$ E C G $67°. \frac{1}{2}$ .. E G $27^m.7$
Now B C = A B = $71^m.$ — G C $11^m.5$ = F E $59^m.5.$
And A B $71^m.$ — E G $27^m.7$ = A F $43^m.3.$ thus

have we the Ship's true *x.* Latitude or Northing $43^{m}.\frac{3}{10}$, and her true Departure or Eaſting $59^{m}.\frac{5}{10}$, given to find her Courſe and Diſtance made good.

By Caſe 6. Plain Sailing.

As *x.* Lat. $43^{m}3$.. R. :: Dep^{r}. 59. 5m. .. T.C. 54°. 54'.
that is, Courſe is N°. 54°. 54'. E.
As S.C. 54°. 54' .. Dep^{r}. 59m. 5. :: R .. Diſt. 72m. 8.

Note, in all theſe Examples where there is Courſe or Courſes, and the Diſt. ſailed in 24 Hours, and the Setting and Drift of the Current in Quality and Quantity is given in the ſame Time; the Navigator need only put down the ſaid Courſe and Drift of the Current among his other Courſes and Diſtances by the Log, when he works his Traverſe Table, which is plain and eaſy, I think, without any Example, as the Learner may prove himſelf by the *Data*, and *Quæſita* of the foregoing Examples. Proceed we to

Caſe 2. *Courſe and Diſt. ſailed, and Courſe and Diſt. made good, given to find the ſetting and Drift of the Current.*

Exam. A Ship ſails (by the Compaſs and Log) N°. 54°. 54'. E. 73m. and then arrives at a Place which is known to bear from the Place ſailed from N. E 100m. (having been deceiv'd by an unknown Current) I demand which way the Current ſets, and how faſt, ſuppoſing the Ship to ſail by the Log. 5 Miles an Hour?

Conſtruction. Let AEF = 54°. 54'. the ∠ of the Ship's Courſe from the N°. A E her Diſt. 73m. AF = *x.* Lat. and F E her Dep. alſo the ∠ CAB the Courſe, A C the Diſt. made good, given to find A B *x.* Lat. and B C. Dep^{r}. See the Scheme to *Caſe* 1. *Ex.* 2. draw E G parallel to A B, and draw

draw E C; ſo ſhall the Angle C E G be the Courſe, and E C the Drift of the Current.

Logarithmetic.

1. As R. . Diſt. $\left\{\begin{matrix}\text{S.C. } 54^{\circ}.54'\\ \text{S.C.C. } 35^{\circ}.06'\end{matrix}\right.$ .. $\left\{\begin{matrix}\text{Dep}^{r}.\text{ FE}\\ x.\text{ Lat. AF}\end{matrix}\right.$ $\left\{\begin{matrix}60^{m}.\\ 42^{m}.\end{matrix}\right.$
AE 73m.

2. As R. . Diſt. AC 100^{m}. : : $\left\{\begin{matrix}\text{S. C.}\\ \text{S.C.C.}\end{matrix}\right\}^{\circ}$: $\left\{\begin{matrix}\text{Dep}^{r}.\\ x.\text{ Lat.}\end{matrix}\right\}^{m}$ $\left\{\begin{matrix}\\ 71\end{matrix}\right.$

3. *x.* Lat. A B 71^{m}.—*x.* Lat. A F $42 = x.$ Lat. E G 29^{m}.
and Dep^{r}. B C 71^{m}.—Dep^{r} F E 60^{m}. = Dep^{r}. G C 11^{m}.
Then have we the *x* Lat. 29^{m}. and Dep^{r}. 11^{m}. of the Current given to find its Courſe and Diſt. by *Caſe* 6. *Plain Sailing*, *i. e.*

As *x.* Lat. 29^{m}.. R : : Dep^{r}. 11^{m}. T. Courſe 20°. 45′.
As S.C. 20°. 45′.. Dep^{r}. 11 : : R . . Diſt. 31^{m}.

So that the Current ſets N°. 20°. 45′. E. 31^{m}. in the Time that the Ship ſailed N E 100^{m}. Now if the Ship ſails 5 Miles an Hour, ſh^{e} will be 20 Hours in ſailing 100 Miles, in which Time the Current ſets 31^{m}. therefore divide 31^{m}. by 20^{h}. the the Quote is 1 Hour, 33 Minutes, the (Horary, or hourly Motion of the Current.

Caſe. 3. Courſe and Diſtance between any two Places, and the Courſe and Motion of a Current that lies between them, given to find what Courſe to ſteer by the Compaſs, or how much to Windward of your true Courſe to ſteer, that ſo the compound Motion of the Ship, may juſt ſet her to her deſired Place or Port.

Example. See the foregoing Scheme.

There are two Ports A and D. bearing S. W. ½ W. and N. E. ½ E. Diſt. 123^{m}. the Current ſets E. 1 ½ Miles an Hour, I demand what Courſe ſhe muſt ſteer from her firſt Port, and what Diſt. by the Log to run, to arrive at (D) her ſecond Port.

Conſtruction. 1. Lay down the Triangle A D B with the Courſe N. 50°. 37′. E. and Diſt. 123^{m}.

2. Then have you the Proportion of the Sides A C & C D, and let E *o* repreſent the Motion of the Current 1 ½ Mile an Hour, and A *o* the Motion of the Ship through the Water 4 ½ Miles an Hour.

Logarithmetic.

Becauſe the Triangles A C D and A *o* E are ſimilar; therefore the Angle A E O is = Angle A D B = 39°. 23′. the Comp. of the Courſe. Then by *Caſe* 2. *Ob. Sailing.*

As A *o* 3,5^{m}. .. S. ∠ AE o. 39°. 23′. : : OE 1,5^{m}. to the S. ∠ E A O 09°. 09′.

The Angle EAB — ∠EA*o* = ∠BAC, that is, 50°. 37′. — 09°. 09′ is = N 41°. 28′. E. the (Ship's) Courſe ſhe muſt ſteer to the Port. Then to find A C the Diſt. to run, by Caſe 1. *Ob. Sailing.*

∠ D 39°. 23′. + ∠ D A C 09°. 09′. = 48°. 32′.

∠^{s} 180 — 48°. 32′. = ∠ACD 131°. 28′. therefore.

As S. ∠ ACD .. Side A D : : S. ∠ ADC .. S^{d}. AC

——S. 48°. 32′. —— 123^{m}. —— S. 39°. 23′. — 104^{m}.

the Diſt. ſailed by the Log is 104^{m}. and the Rate of Sailing is 4 ½ Miles an Hour; therefore divide 104 by 4.5. the Quote is 23 Hours that the Ship will be in Sailing from A to D.

Note. The faſter the Ship ſails, the leſs ſhe needs to lye to Windward of her true Courſe againſt the Current, which is neceſſary to be known.

I might inſert many other Curioſities in Current Sailing; but theſe being the moſt uſeful, I forbear to enlarge in this Place; therefore ſhall conclude this Sailing with another Method, to find where there is a Current at Sea, which way it ſets, and how faſt, and of turning to Windward in a Current.

The firſt may be done by comparing the Dead-reckoning outwards, with the Reckoning homewards after this Manner.

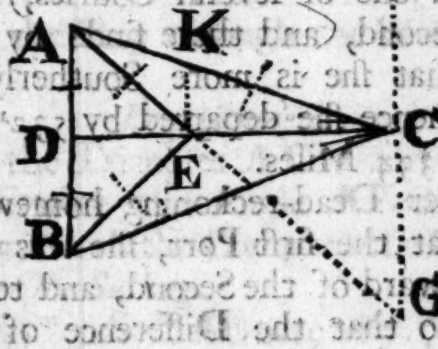
Exam. Admit a Ship ſail from a certain Port (either upon one or ſeveral Courſes,) till ſhe arrives at a ſecond, and there finds by her Dead-reckoning, that ſhe is more Southerly than the Port from whence ſhe departed by 532m. and more Weſterly by 334 Miles.

But by her Dead-reckoning homeward, when ſhe arrived at the firſt Port, ſhe was only 487m. to the Northward of the Second, and to the Eaſtward 300m. ſo that the Difference of theſe two Reckonings is 45m. Southerly, and 34m. Weſterly, which by the preceding Problems, the Current ſets S. 37°. W. its Motion or Drift 56m. Now let us ſuppoſe the Ship ſailed from the firſt Port to the ſecond in 4 Days, and from the ſecond, to the firſt in 5 Days, which is 9 Days time the Current ſet S. 37°. W. 56m. therefore the Currents Motion is S°. 37°. W. 6m. $\frac{6}{10}$. of a Mile in a Day.

2. *Turning to Windward in a Current.*

Examp. 1. COURSE and Motion of the Current, and the Courſe and Diſt. between two Ports, with the Point of the Winds blowing, and how near the Wind the Ship will lie, being given to find how long ſhe muſt lie upon each Tack to gain her Port; ſuppoſing alſo that the Horary Diſt. ſailed by the Log be alſo given.

Admit two Ports bear North and South Diſt. 270m. the Wind at South, and a Current ſets South 2m. an Hour, a Ship is bound directly to Windward the Southermoſt Port, and can lie within 72°. of the Wind, gets her Starboard Tacks aboard and ſails 4m. an Hour by the Log; it is demanded how long ſhe muſt lye upon each Tack to gain the Port, and what Courſe ſhe makes good?



Construction. 1. With the Dist. of the Ports AB 270^{m}. and Deg. 72°. from the Wind at S°. project the Triangle A B C, (as directed in *Prob.* 1. of turning to Windward in *Oblique Sailing* foregoing.)

2. A C is = B C, let fall the perpendicular C B, and you have the right angled Triangle A C D, equal to the right angled Triangle B C D, and also the Side A D equal to D B = ½ A B 270^{m}. *viz.* 135^{m}. and the Angle D C A = D C B = the Comp. of the ≤ C A B or C B A 72°. *viz.* 18°. Then

Logarithmetic.

As S. ≤ A C D . Side A D : : R. Side A C.
S. 18° ——— 135^{m}. ——— S. 90 ——— 436^{m}.

the Dist. upon each Tack to gain the Port, if there had been no Current. Which 436 divided by 4^{m}. sailed in an Hour Quotes 109 Hours, in which the Ship sails from A to C, but the Current sets South 2 Miles an Hour, and that in 109 Hours is S. 218^{m}. *Ergo,* draw the South Line C G = 218^{m}. and also A G which shall represent the Compound Motion of the Ship, or Course made good; but because she is to lye upon that Tack, but only till she be got half way to the intended Port, observe where the Line A G cuts the Perpend. D C as in E, draw A E and B E, so shall A E be the Dist.

Dist. on the Starboard, and E B the Dist. on the Larboard Tack, to fetch the Port B, and the Angle D A E the Course made good by reason of the Current.

But to find how far the Ship must sail by the Log, by that time she will be at E by the help of the Current, draw E K parallel to G C, this Parallel shall cut A C proportionably by *Euclid.* Lib. 6. Prop. 2. *viz.*

As A G .. A E :: A C .. A K, the Dist. sailed by the Log, (which found by the following Calculation) is 166. ½. this divided by 4, the Miles sail'd by the Log in an Hour, gives 41 Hours, 37 Minutes, the time to stand upon the Starboard Tack, and the same time, on the Larboard Tack, to fall in with the Port bound for at B.

Calculation Logarithmetic in the Oblique Triangle.

A C G is given, the Side C G 118^{m}. and the Side A C 436^{m}. with the Angle between them A C G 108°. (for C A is a Line W. 18°. N°. and C G a South Line, and from the W. 18°. N°. to the S°. is 108°.) to find the Angle C A G, by *Case* 3. of *Oblique Sailing* foregoing, *viz.*

As Z^{s} S^{ds}. 654 .. *x* S^{us}. 218 :: T. ½ Z unknown, — < 36° .. T. of ½ their *x* 18° : 32′ — Then the ½ Z 36° .. 00′ — ½ *x* 13° : 32′ = < C A G 22° : 28′ And the Angle D A C = B A C 72°. made less by the < C A G 20° : 28′ is 49° : 32′ for the < D A E, whose Comp. to 90° is the < A E D 40° : 28′. as you may see in the Scheme.

To find the Dist. made good on each Tack, A E = E B.

As S < A E D .. S^{d} A D :: B .. S^{r} A E. — S 40° : 28′ — — 35^{m} — S 90 — 208^{m}. the Dist^{s} made good on each Tack.

Then for the Dist^{s} ſail'd by the Log A K (which by the help of the Current ſhe is carried to E.) in the Triangle A K E, is given A E 208^{m}. and the Angle A K E = ∠ A C G 108°. Alſo the Angle K A E = ∠ C A G 22°: 30′, and the ∠ A E K = A G C = ∠ D A E 49°: 37. *viz.* All the Angles and oppoſite Side A E, to find another oppoſite Side A K; *i. e.* by Caſe 1. *Oblique Sailing.* Thus;

As S ∠ A K E .. S^{d} A E :: S ∠ A E K .. S^{d} A K.
S 180°--108 = 72° — 208^{m} — S 49°: 37′ — 166^{m} ½.

Which divided by 4, the Miles ſail'd in an Hour, the Quote is 41 Hours, 36 Min. that ſhe muſt lie upon the Starboard Tack; in which time ſhe is carried by the help of the Current, from A to E; and then lying the ſame time upon her Larboard Tack, ſhe will arrive at her intended Port B: So that in 83 Hours 12 Minutes, ſhe performs the Voyage of 270 Miles, altho' upon a Wind, by the help of the Current; which had there been no Current would have requir'd (at the ſame Rate of Sailing) 218 Hours, or 9 Days, 2 Hours.

Examp. 2. When the Current ſets Obliquely; that is, neither N. S. E. or Weſt, and the Port bound to is alſo upon any other Point, and not on the aforeſaid four Cardinals.

Suppoſe a Ship makes her way good within 6 ⅓ Points, (or 73°: 07′) from the Wind, being bound to a Port at P, bearing from A S. W. by S. ¼ W. Dist^{e} 476^{m}. the Wind at S. by W. A Current ſetting S. by E. 110 Miles in the ſame time that the Ship ſails 300 Miles; I demand the Courſe and Dist^{s}. the Ship muſt ſail upon her Starboard Tack A D, and what upon her Larboard Tack D E, to gain the ſaid Port at P?

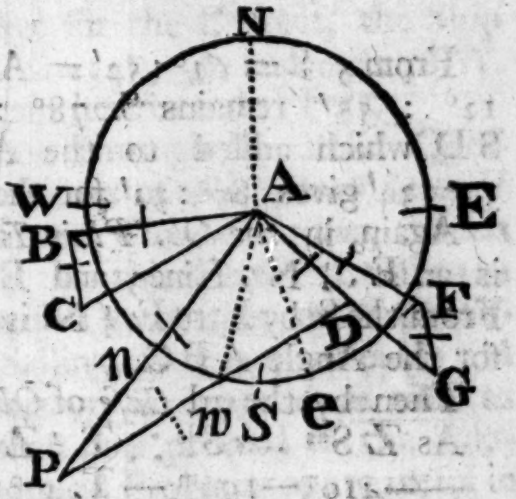
Projection.

Projection.

1. The Circle deſcrib'd and quarter'd as formerly directed.

2. Set off 1 Rhumb, or 11° : 15′ from S to *w*, and from S to *e*, and draw A *w*, for the Wind-Line, and A *e*, for the Current's Motion, *a* S *b*, E. Line.

2. Set off 3 Points ¼ from S, towards W. and draw a S. W. by S ¼ Weſt-line, and make A P = 476m. the Diſt of the Port.



3. Set off 6 ½ Points, or 73° : 07′. from *w*, the Wind-line, both Ways, to B and F, and draw A B and B F, which is her Way upon the Larboard and Star-board Tack, without a Current: Make A B and B F, each equal to 300m. and from B and F, draw Parallels to A *e*, (the Line of the Current's Motion) and make B C and F G, each equal to 110m. and draw A C and A G, ſo ſhall C and G be the Place of the Ship on either Tack, with allowance for the Current.

4. Suppoſe the Ship gets her Starboard Tacks a-board at her firſt ſetting out, then draw from P a line parallel to A C, to cut A G in D, the Place where the Ship muſt Tack, ſo ſhall A D be her true Diſtance on her Starboard, and A P her Diſtance on the Larboard Tack, to gain her deſired Port at P.

Operation Logarithmetic.

In the *Oblique Plain* Triangle A G F, F A is a N. W. by W. ½ Line, and F G a S. by E. Line; from the one to the other is 11 ½ Points equal to 129° : 22. Therefore, by *Caſe* 3. *Ob. Sailing*,

As

As Z S^{ds} .. x S^{ds} . : : T. $\frac{1}{2}$ Z $\angle^{s}$ .. T. $\frac{1}{2}$ x $\angle^{s}$.
——410^{m} —— 190^{m} —— To 25° : 19′ .. T. 12° : 24′
To which add 25 : 19

Sum is equal to the $\angle$ A G F = 37 : 43

Diff^{s}. is the $\angle$ F A G = 12 : 55

From 5 $\frac{1}{2}$ = 61° : 52′ = A F. take the $\angle$ F A 12° : 55′ remains S. 78° : 57′. E, the Arch S D which added to the Arch S n, 3 P $\frac{1}{4}$ = 36° : 34′ gives 85° : 31′ for the $\angle$ P A D.

Again, in the *Ob. Plain Triangle*, A B C, B A is an E. $\frac{1}{2}$ N°. Line; and B C a S: by E. Line; From the S. by E, to E. $\frac{1}{2}$ N. is 7 Points $\frac{1}{8}$ = 84° : 22′ for the Angle A B C.

Then by the 3d *Case* of *Oblique Plain Sailing*.

As Z S^{ds} .. x S^{ds} : : T. $\frac{1}{2}$ Z $\angle^{s}$ .. T $\frac{1}{2}$ x $\angle^{s}$.
——410^{m} —— 190^{m} — T. 47° : 45′ — T $\frac{1}{2}$ 27° : 05′
$\frac{1}{2}$ Z 47° : 49′ less $\frac{1}{2}$ x 27° : 05′ = 20° : 44′ for the $\angle$ B A C; which taken from the Arch S B 7 $\frac{1}{2}$ Points = 84 : 22′ remains the Arch S C = S 63° : 38′ West. So that the Line C A, or its Parallel P D, is a N. 63° : 38′ E. Line; and the Line P A is N. E. by N. $\frac{3}{4}$ E. or N° 36° : 34′ E. their Difference; or the Angle contain'd between them is, 27° : 04′, for the Angle A P D.

Also the Line D A is N°. 48 : 57′ West; and the Line D P, Parallel to C A, is S. 63° : 38′ W. the Angle or Arch between these two is, 67° : 25′. for the $\angle$ A D P. (thus 48° : 57 + 63° : 38′ = 112° 35′ — 180 = 67° = 67′ : 25′)

So we have now given in the *Ob. Triangle* A P D the $\angle$ A, $\angle$ P, and $\angle$ D. and Op. Side A P, to to find the other two Sides by *Case* 1. *Ob. Plain Triangles.*

As S. $\angle$ D .. S^{d} A P : : S. $\angle$ P. : . S^{d} A D.
— S. 67° : 25′ —— 476^{m} — S. 27° : 04′ — 204^{m}. $\frac{6}{10}$.

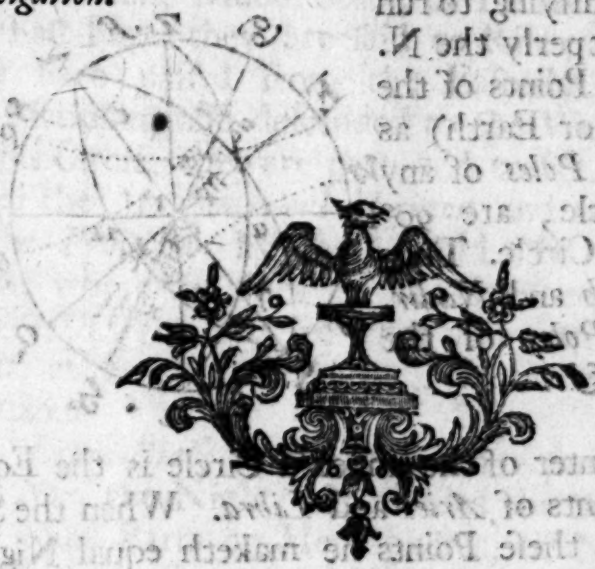
The

The Distance made good on her Starboard Tack.

As S ∠ D .. S^d. A P : : S. ∠ P A D .. S^d. D P.
— S. 67° : 25° — 476 — S. 85° : 31′ — 514^m.

the Distances made good on her Larboard Tack. So that with allowance for the Current, the Ship must sail S. 48° : 57′ E. 234^m, $\frac{8}{10}$, and 63° : 38 W. 514^m. and she will gain her intended Port.

Thus have we gone through the useful Questions in the several Kinds of *Rectilinear Sailing:* and as for Spherical or *Circular Sailing*, (which should have follow'd in this Place) I refer the Learner to a Treatise I've written on that Subject, wherein that Sailing, as it is more exact and difficult than the former, is render'd as easie as *Plain Sailing*.— I shall now proceed to the Solution of such Astronomical Problems as are useful in *Navigation*.



CHAP. V.

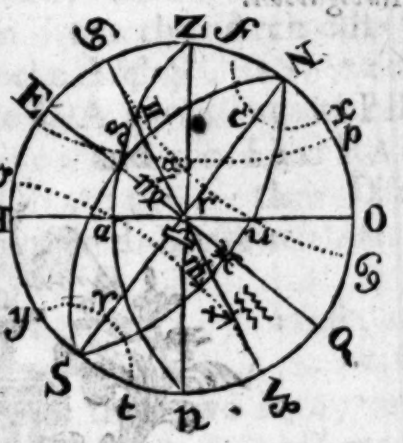
Aſtronomical Definitions.

I. *Of Points in the Heavens.*

1. THE *Zenith* in *Arabick*, or *Vertex* in *Latin*, is the Point in the Heaven directly over our Heads, as Z.

And the *Nadir* in *Arabick*, is the Point under our Feet, as *n*.

2. *Poles* of the World, (or Equinoctial) a *Greek* Word, ſignifying to run about, properly the N. and South Points of the Heavens (or Earth) as N. and S. *Poles* of any great Circle, are 90° from that Circle. Thus the *Zenith* and *Nadir*, are the *Poles* of the Horizon, *&c.*



The Center of the annex'd Circle is the Equinoctial Points of *Aries* and *Libra*. When the Sun cometh to theſe Points he maketh equal Nights and Days all over the World, which is about the 10th of *March*, and 12th of *September*, from whence they are alſo termed *Vernal* and *Autumnal* Points.

The

The Center ♈ and ♎, repreſents the Eaſt, or Weſt Points of the Horizon, Morning and Evening; as alſo the Hours of 6 and 6, Morning and Evening. H is the South, and O the North Point of the Horizon.

2. *Of Great Circles.*

The Meridian is derived from the Latin *Meridies*; *i.e.* Mid-day. This Circle paſſeth thro' the Poles of the World, and the *Zenith* and *Nadir*; alſo the North and South Points of the Horizon, unto this Circle (any Day in the Year) when the Sun cometh, 'tis Noon or Mid-day; and when the Moon, Stars, or Planets, come to touch this Circle, they are then ſaid to be upon the Meridian, or at the higheſt they will be that Night. This Circle is repreſented by the primitive Circle H ZOn.

2. *Horizon* is derived from the *Greek* Word *Horizen*, to bound, encloſe, or terminate our Sight, and divides the upper, or viſible, from the lower and inviſible Hemiſpheres. To this Circle, when either the Sun, Moon, Stars, or Planets, come on the Eaſt Part, they are ſaid to Riſe; and when they have paſſed from the Eaſterly Point by the Meridian, and deſcended to the Weſtern Part of this Circle, they are then ſaid to Set. This is called the *Mathematical Horizon*, and repreſented in the *Projection* by the Line H ♈O. But that Circle where the Heaven and Sea ſeem to meet, as far off as you can ſee when you turn your ſelf about at Sea, is called the Natural or Senſible Horizon.

3. *Equinoctial*, from the Latin *Equus*, Equal; and *Nox*, the Night. It divides the Sphere into two equal Parts or Hemiſpheres, of North and South, lying in the middle between the Poles; whence by the Antients, it is called *Cingulum Mundi*, the Girdle of the World: Thoſe that live under it have equal Days and Nights; and thoſe

are said to have a direct Sphere, because the Sun and Stars ascend directly above the Horizon, and descend as directly under it, the Poles of the World being in their Horizon; and we, and other Inhabitants, that have North or South Latitude, an Oblique Sphere, that is, the Sun and Stars rise and set at Oblique Angles to the Horizon, making unequal Days and Nights. Yet twice a Year, as was hinted before, have our Days and Nights equal, when the Sun cometh to this Circle. It is noted in the Scheme by E Q: And *Note*, that the Distances between the Equinoctial and Horizon of any Place, is equal to the Comp. of its Latitude, as in the Scheme E H = N Z = O Q = N S.

Again, all the time the Sun is to Northward of the Equinoctial, which is our Summer; those (if any there be that inhabit the North Pole of the World (and are said to have a parallel Sphere, because the Sun and Stars go parallel or round them in 24 Hours) have six Months Day, (except what the Sun appears by Refraction) and during our Winter, which is the time when the Sun is to the Southward of the Equinoctial, they have six Months Night; and the contrary to those (if any) under the South Pole of the World.

4. *Ecliptick.* So called from the *Greek* Verb *Ecleipo*, which signifies to fail, or want Light; because under this Line the Sun and Moon is in the middle of the Zodiack, and always suffer their Eclipses. This Circle is called *Via Solis*, the Sun's Way, or Path, or Orbit, because he never goes out of it: This Circle is elevated above the Equinoctial in North Latitude 23° ½, equal to the Sun's greatest Declination, and is as much depressed below the Equinoctial in the Southern Hemisphere. It cutteh the Horizon in the East and West Point ♈, as the Equinoctial did, and is represented in the Scheme by ♋ ♈ ♑, and hath charactered upon

on it the twelve zodiacal Signs; *viz.* The ſix Northern Signs, ♈ ♉ ♊ ♋ ♌ and ♍, being on that half that is above the Horizon: And the ſix Southern Signs, ♎ ♏ ♐ ♑ ♒, and ♓, on the other half, which is below the Horizon; and on this Line we count the Sun and Stars Longitude and Place in ſuch a Sine, which is their Diſtances from the two Equinoctial Points, ♈ and ♎.

5. *Of the Colures or prime Vertical.*

Colures. So called from the *Greek* Verb *Colào*, which ſignifies to join or glew together, becauſe the other moveable Circles of the Sphere are (as it were) conglutinated, or united, by theſe. The Equinoctial *Colure*, *Prime Vertical*, or Circle of Eaſt and Weſt, noted in the Scheme by Z ♈ *n*, paſſeth through the *Zenith* and *Nadir* Points, and alſo through the Eaſt and Weſt Points of the Horizon unto this Circle, when the Sun, Moon, and Stars do (in their Motions) arrive, they are then due Eaſt or Weſt.

The Solſtitial *Colure* paſſeth through the Points of *Cancer* and *Capricorn*, the *Zenith*, *Nadir*, North and South Poles, and North and South Points of the Horizon, and is noted in the Scheme by the Primitive Circle or Meridian E N Q S. Theſe two *Colures* divide the Equinoctial, Ecliptick and all the Heaven into four equal Parts, and ſhew the four principal Points of the Ecliptick, to which, when the Sun comes, he diſtinguiſhes each Quarter of the Year, *Spring*, *Autumn*, *Summer*, and *Winter*.

6. *Of Hour Circles*, or *Meridians.*

They meet together in the Poles of the World, and croſſing the Equinoctial at Right-angles, and ſuppoſing the Equinoctial divided into 24 equal Parts, or Hours of a Natural Day: Theſe Meridians may be drawn through every 15°. which is 1 Hour of Time; but if they paſs through other Parts of the Equinoctial, dividing it unequally; then

then do thoſe Hour-Circles repreſent unequal Spaces of Time, according to the Diſtance they are from the Meridian, or outward Circle of 12 at Noon and Midnight. The Axis of the World, N ♈ S, is the ſix o' Clock Hour-line Morning and Evening, called alſo the Prime or firſt Meridian. So N. ☊ S. and N. ♓ S, are unequal Meridians.

7. *Of Azimuth Circles.*

Azimuth is an *Arabick* Word, ſignifying Vertical Circles, meeting together in the Zenith and Nadir Points, (as the Hour Circles do in the Poles of the World) and divide the Horizon at Right-angles, either equal, or unequal, as the Hour-Circles did the Equinoctial. They are repreſented in the Scheme, by Z A *n*.

8. *Circles* of Longitude of the Sun or Stars, cut the Ecliptick at Right-angles, and interſect each other in the Poles thereof, which are 23° : ½ from the Poles of the World.

Arches of great Circles.

1. The Sun or Stars Altitude, or Height in any Lat. is an Arch of an *Azimuth Circle*, contain'd between the Sun and the Horizon, as E ☊ *p*.

2. *Amplitude* Lat. Width, is an Arch of the Horizon, and ſheweth the Diſtance that the Sun or Star doth riſe or ſet from the true Eaſt or Weſt Points of the Horizon, towards the North or South Points thereof, as ♈ *u*.

3. *Azimuth* is an Arch of the Horizon, contained between the Point where the *Azimuth Circle* that the Sun is in cuts the Horizon, and the North and South Points of the Horizon: The Sun's Azizimuth from the South is repreſented in the Scheme by H *a*; from the North by the Arch O *a*.

4. *Right*

4. *Right Aſcenſion* is an Arch of the Equinoctial, between the beginning of *Aries* (or in Aſtronomical Operations, between the neareſt Equinoctial Point) and that Point of the Equinoctial that comes to the Meridian with the Sun or Star; as ♈ ♓.

5. *Oblique Aſcenſion* is an Arch of the Equinoctial, contain'd between the next Equinoctial Point, and that Point of the Equinoctial that riſes with the Sun, or Star.

And *Oblique Deſcenſion* is the Arch of the Equinoctial which ſetteth with the Sun, or Star.

6. *Aſcenoſinal Difference* is the Difference between the Right and Oblique Aſcenſion; or it is an Arch of the Equinoctial contain'd between the Points of Right and Oblique Aſcenſion; and conſequently ſhews how long the Sun riſes or ſets before or after the Hour of 6: Or ½ the Time that a Star above or below our Horizon exceeds, or wants, of 6 Hours.

7. *Longitude* of the Sun or Stars, is an Arch of the Ecliptick, contain'd between the next Equinoctial Point and the Sun, or Star; as ♎♍.

8. *Declination* is an Arch of the Meridian, contained between the Equinoctial and the Sun, as ☉ ♋ ♓ *u*, and ſheweth how far the Sun, or Star is to the Northward or Southward of the Equinoctial.

9. *Latitude* of a Star is an Arch of a Circle of Longitude, comprehended between the Star and the Ecliptick.

Leſſer Circles.

They are commonly parallel to ſome great Circle; and hence called Parallels: as Parallels of Altitude; as E ☊ *p*; and Parallels of Latitude, or Declination; as ♋.*u* ♋.

The *Tropick* (from the Greek, *Trope*; a converſion, or turning: Becauſe the Sun is there in

its greateſt Declination from the Equinoctial, and turns backward) of *Cancer*, is a Parallel to the Equinoctial, diſtant 23° ½ Northward, and the Tropick of *Capricorn*, the like Diſtance Southward; as ♋ ♋, and ♑ ♑. The Artick, (or North polar) Circle is diſtant from the Equinoctial Northward, and the Antartick (or South polar) Circle, Southward, *c*6 ½; as *f c x*, and *y r t*. Theſe two Tropicks, and two polar Circles, do divide the Globe into 5 Zones. (*Zona* is *Latin* for a Girdle) the Spaces between the two polar Circles and their reſpective Poles, are called the two *Frozen Zones*. The two Spaces between the polar Circles and the Tropicks of *Cancer* and *Capricorn*, the *Temperate Zones*: And the middlemoſt between the two Tropicks, the *Burning Zone*.

Angles.

The Sun's greateſt Declination is the Angle that the Ecliptick makes with the Equinoctial, as the Angle E ♈ ♋. or Q ♎ ♑. = 23°. 30′.

The Sun's Azimuth is an Angle at the Zenith, contained between the Azimuth Circle the Sun is in; and the Prime-Vertical (if reckon'd from the Eaſt or Weſt) or the Meridian, if reckoned from the North or South: Thus the Angle ♎ Z *a*, is the Sun's Azimuth from the Eaſt or Weſt; but O Z *a* is the Sun's Azimuth from the North, and *a z b* his Azimuth from the South, either of which may be meaſured on the Horizon H O from the Line of ½ Tangents.

The Hour of the Day is an Angle made at the Pole, between the Meridian of the Sun, and the Meridian of the Place: Thus the Angle ☊ N. E. is the Hour from Noon, when the Sun is any where in the Meridian N. ☊ S. and ♈ N ☊ is the Angle from 6 a-Clock in the Morning, ♈ N ♓ the Angle of the Hour from 6 in the Evening, and ♓ N Q

the Angle of the Hour from Midnight; all theſe may be meaſured from the Equinoctial by a Line of half Tangents; becauſe all the Angles in *Aſtronomy*, may be reckoned Arches of thoſe great Circles that are 90 Deg. diſtant from the angular Point.

I thought here to have given you the Orthographic and Stereographic Projection of the Sphere on any Circle, and the Doctrine of Spherical Triangles, and all the Variety of Queſtions in Practical *Aſtronomy*; but that being ſufficient to make a Treatiſe it ſelf, which would exceed the deſign'd Limits or Bounds of this ſmall Book; I rather chooſe, to ſupply that defect by inſerting ſuch practical Problems of *Aſtronomy*, as are of moſt uſe in Navigation, and Aſtronomical Tables ready calculated from them; and as for the curious Learner, that would gain a further Improvement in *Aſtronomy*, I refer him to the latter Part of my *Engliſh Academy*, where I hope he may receive ample Satisfaction, and paſs on to.

Aſtronomical Problems.

Prob. 1. *Given the Day of the Month; required the Sun's Place in the Ecliptick.*

KEEP in Mind the Days on which the Sun enters the ſeveral Signs, which are theſe;

♈	♉	♊	♋	♌	♍
Mar. 10.	*Ap.* 9.	*May* 10.	*June* 11.	*Jul.* 12.	*Aug.* 12.
♎	♏	♐	♑	♒	♓
Sep. 12.	*Oct.* 12.	*Nov.* 12.	*Dec.* 11.	*Jan.* 9.	*Feb.* 8.

Rule. If at the Day given, the Sun be in the Sign proper to the given Month; ſubtract the Day the Sun enter'd that Sign from the Day given;

ven; multiply the Remainder into 59′. 8″. 19‴. 43⁗. 47⁗′. 21⁗″. 29⁗‴. (the Sun's Motion in the Ecliptick in one Day) but 59′. 8″. may suffice (for common Use) so you have the Degree of that Months Sign the Sun is in.

Exam. I demand the Sun's Place on the 25th Day of *August*? 25—12=13×59′.8″.=12°.58′.44″.♍. See the *Operation*;

	′	″.
	59	8
		6
°		
5	54	48
		2
11	59	36
+	59	08
⊙ Place	12	58 : 44 of ♍.

Multiply by the Ratio of 12 Days, *i. e.* 6 and 2, and add to the Product 59′. 8″. for the odd Day.

Exam. 2. If the Sun be in a Sign different from the proper Sign of the Month; then from the Number of Days contained in the preceding Month, subtract the Day of the Sun's entring into that Month's Sign to the Remainder, add the Day of the Month given; that Sum multiplied into 59′. 8″. exhibites the Degree the Sun is in.

Exam. August the 6th, the Sun is in ♌ 24°. 38′ 21″. for July 31 Days—12 Days in *Aug.* the Sun enters ♌) =19 which added to the given Day of the Month 6 is 25.

Operation.

31—12+6=25 Days.
59′ . 8″.
8

7 : 53 : 04
3

23 : 39 : 12
+ : 59 : 08

24 : 38 : 20 of ♌

Multiply by the Ratio of 24. *viz.* 8 and 3, and add to the Product 59′. 8″. for the odd Day.

Lemma 1. The Sun's Place given to find the neareſt Equinoctial Point.

Rule. Divide the Ecliptick into 4 Quadrants or Quarters thus;

1. Qr. ♈. ♉. ♊.
2. Qr. ♋. ♌. ♍.
3. Qr. ♎. ♏. ♐.
4. Qr. ♑. ♒. ♓.

While the Sun is in the firſt and laſt Quadrants, ♈ is the neareſt Equinoctial Point; and when in the middle two; ♎.

In the firſt Quadrant, the Sun's Longitude is the Diſtance from the neareſt Equinoctial Point.

In 2. Qr. 180°.—☉s. Long.
In 3. Qr. ☉s. Long.—180.
In 4. Qr. 360 — ☉s. Long.
} is the Diſtance.

Prob. 2. The Sun's greateſt and leaſt Meridian Altitude (taken at Noon on the longeſt and ſhorteſt Days of the Year at *London*) given, to find the Sun's greateſt Declination, and the Latitude of the Place?

Example. With a Quadrant, (Foreſtaff) or other Inſtrument; ſuppoſe I had obſerv'd on

June / *Decemb.* } the 11th } ⊙ Merd. Alt. to be { 61 : 58 / 14 : 58

Their *x.* is the Diſt. of the Tropicks = 47 : 00

The ½ of which is ⊙ great Declin. = 23 : 30

Merid. Alt. { 61 : 58 / 14 : 58 } taken from

90°. gives { 28 : 02 / 75 : 02 } ⊙ Zenith

Diſtance on { *June* / *December* } 11th.

To ⊙ Zenith Diſtance — S°. 28 : 02 } *June* 11th.
Add ⊙ Declin. — — N°. 23 : 30 }

Lat. of *London* N°. = 51 : 32 N°.

From ⊙ Zen. Diſt. 75 : 02 S. }
Take ⊙ Declin. — 23 : 30 S. } *Dec.* 11th.

Reſt. Lat. *London* 51 : 32 N°.

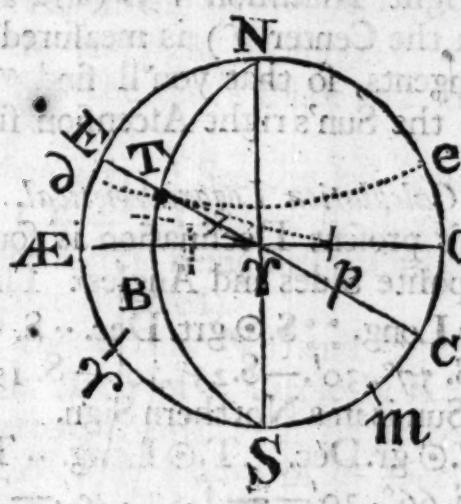
Prob. 3. Given the Sun's greateſt Declination and Place; required the preſent Declination, and Right Aſcenſion?

Exam. The Sun in 27°. 30'. of ♉ *Taurus*, and and his greateſt Declination, (always) 23°. 30'. N°. (or S°.) given, what is his preſent Declination, and Right Aſcenſion?

Projection Geometrical.

1. With the ½ Tangent 90°. = Chord of 60°. deſcribe the Meridian or Circle ÆNQS, and quarter it as before taught.

2. Make



2. Make the $< Æ \gamma E = 23°. 30'.$ *i. e.* make Æ E = Chord of $23°. \frac{1}{2}$, and draw the Line E γ C, ſo ſhall N repreſent the North Pole, S the South Pole Æ γ Q the Equinoctial; and E γ C the Ecliptick.

3. The ☉ in ♉ 27°. 30'. his Longitude from γ is 30°. + 27°. 30'. = 57°. 30'. (for every Sign contains 30°.) therefore ſet off the half Tang. of 57°. 30'. from γ to T. ſo ſhall T be the Sun's Place in the Ecliptick.

4. By *Prob.* 8. *Geom. Prob.* thro' N. T. S. deſcribe a Circle (or Meridian) N. T. S, and its done, and the Perpend. B. T. is the ☉ preſent Declination, the Baſe γ B his right Aſcenſion (in the right angled Spheric. Triangle γ B T right angled at B,) the Declination is thus meaſured (Stereographically) 1. Lay a Ruler over N. and B, to cut the primitive Circle or Meridian in the Point *r*. 2. Lay off 90° of the Chords from *r* to *m* on the primitive Circle. 3. Lay a Ruler over *m* and N, to cut the other Diameter or Equinoctial Æ Q in *p*, (which is called the Pole of the Oblique Circle or Meridian N B S.) 4. Lay a Ruler over P and T, to cut the primitive in *d*. ſo ſhall Æ *d* (= B T) be equal to the Chord of the Sun's preſent Declination.

5. The right Aſcenſion ♈ B (and all Semidiameters from the Center ♈) is meaſured by a Line of half Tangents, ſo that you'll find ♈ B = half Tangent of the Sun's right Aſcenſion from ♈.

Calculation Logarithmetical.

The Sun's preſent Declination is found by the Rule of oppoſite Sides and Angles: Thus,

As ℞ .. S.☉ Long. :: S.☉ grt. Dec. .. S. ☉ pr. Decl.
—S.90°.—S. 57°. 30′.—S.23°.30′.—S. 19°. 39′. N°.
becauſe the Sun is in a Northern Sign.

As ℞. .. S.C.☉ gr.Dec.:: T.☉ Long. .. T.☉R.Aſc.
—S. 90°.—S. 66°. 30′——T.57°. 39′.—T. 55°. 13′.
from ♈.

By Gunter's *Scale Inſtrumental.*

The Ext. reaches } from { S. 90°. to S. 57°. 30′. ☉ Longit. / T. ☉. gr. Dec. 23°. 30′. to the S. ☉ preſent Declin. on the Line of Sines, *viz.* 19°. 39′.

The Ext. reaches } from { S. 90°. to S. 66°. 30′.. / S. 57°. ½ to T. 55°. 13′. } on { Sines. / Tang.

N. B. In the 1ſt Quadrant ♈ B is the right Aſcenſion.

In 2. Qr. 180— ♈ B
In 3. Qr. 180+ ♈ B } is the right Aſcenſion.
In 4. Qr. 360— ♈ B

By this Problem may the Tables of the Sun's Declination and right Aſcenſion, (at the latter End of this Book) be calculated the Sun's Place in the Ecliptick given; for the ☉ greateſt Declination is always 23°. ½, but by the exact Obſervations of Mr. *Flamſteed* 23°. 29′.

By the reverſe of this Problem alſo may *Prob.* 4. and 5. be perſormed, in which I ſhall (to avoid Prolixity) be very brief, and leave the *Operation* to the Learner.

Prob.

Prob. 4. Given the ☉ preſent Declination 19°. 39 min. North, and right Aſcenſion 55 deg. 13 min. from ♈, to find the Sun's Place and greateſt Declination.

Conſtruction. [See the laſt Scheme.]

1. Make ♈ B = ½ Tangent ☉ Right Aſcenſion 55°: 13′. (the Circle being firſt deſcribed and quartered, as before directed).

2. Thro' the Points N B and S, deſcribe the Meridian (or Arch of a Circle N B S) and find the Pole thereof, as directed in the preceeding *Prob.*

3. Make Æ *d* = Chord of ☉ Decl. 19°: 30′; and laying a Ruler over *d* and *p*, to cut N *b* S in T. Laſtly, thro' T and the Center ♈, draw the Ecliptick Line E T ♈ C, and it's done.

Calcul. Logarithmetic.

As ℞ .. S. C. ☉ pr. Dec. :: S. C. ☉ R^{t} Aſc .. S. ☉ Place, or Long. 57°: 30′ — 30° = 27°: 30′ of ♉.
As T. ☉ pr. Dec. .. ℞ :: S. ☉ Rt. Aſcen. .. T. C. of the ☉'s greateſt Declination, 23°: 30′.

Prob. 5. Given ☉ $\left\{\begin{matrix}\text{preſ}^{t}\\ \text{great}\end{matrix}\right\}$ Dec. $\left\{\begin{matrix}19°:39'\ \text{N.}\\ 23°:\frac{1}{2}\end{matrix}\right.$

Req. ☉ $\left\{\begin{matrix}\text{Longitude.}\\ \text{Right Aſcenſion.}\end{matrix}\right\}$

Projection. [See the laſt Scheme.

1. Make Æ E = Chord 23°: 30′. and draw the Ecliptic E ♈ C.

2. Make N *d* and N *e* = Com. Declin. *viz.* 70°: 21′ from the Chords. Then with the Tang. of 70°: 21′ and one Foot in E and *e*, deſcribe two Arches to interſect each other above N. Then with the ſame Diſt.^{s}. one Foot in the ſaid Interſection, deſcribe the Parallel of the Sun's (Diurnal Courſe)

Courſe) Declination d T e, to cut the Ecliptick Line E ♈ in T.

3. Through the 3 Points N T S, deſcribe a Circle, or Meridian, NTBS, and it's done. Then,

Logarithmetical.

As S. ☉ great Decl. .. S. ☉ preſ. Decl. :: ℞ .. S. ☉ Long. from ♈ 57° : 30′.

℞ .. T. ☉ preſ. Decl. :: T. C. ☉ great Decl. .. S. ☉ Right Aſcenſion from ♈ 55° : 13′.

Prob. 6. If the Sun's Long. and Right Aſcenſion were given, to find the Sun's preſent and greateſt Declination, which is the reverſe of the laſt *Prob.*. Then it is,

As ℞ .. T. ☉ R^t. Aſcen. :: T. C. ☉ Long .. S. C. ☉ preſent Declination.

Again.

As S. C. ☉ R^t. Aſcen. ℞ :: S. C. ☉ Long. .. S. C. ☉ greateſt Declination.

Prob. 7. If the Sun's Longitude and preſent Declination were given, to find the Sun's greateſt Declination and Right Aſcenſion, the Proportions are,

As S. ☉ Longit. .. ℞ :: S. ☉ preſent Decl. .. S. ☉ greateſt Declination.

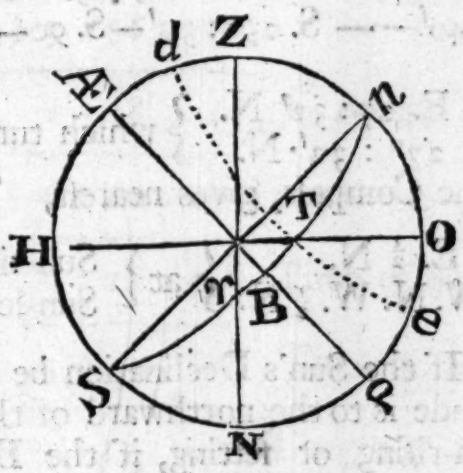
As S. C. ☉ preſ. Decl. .. ℞ :: S. C. ☉ Long. .. S. C. ☉ Right Aſcenſion.

Prob. 8. The Latitude of the Ship (or Place) 43°: 20′ N°. and the Sun's Declination (19° : 39 N′) given; to find the Sun's Amplitude, and aſcenſional Difference, which is the time of the Sun's Riſing or Setting from the Hour of 6.

Projection.

1. The Circle being deſcribed (with a Chord of 60°) and quartered, make Z the *Zenith*, N the *Nadir*, and H ♈ O, the Horizon; H the South; O the North; and ♈ the Eaſt or Weſt Points thereof.

2. Make



2. Make O *n*, and Z Æ, each equal to the Chord of the Lat 43° : 20′ N. and draw the Axis N ♈ S, and the Equinoctial Æ ♈ Q.

3. Becauſe the Declination given is North, deſcribe a Parallel of the Sun's Declination, (70° ; 21′.) from *n* the North Pole, as was directed in the 5th Problem foregoing, and it will cut the Horizon in T.

4. Through the Points *n* T and S, deſcribe the Meridian Circle *n* T S, which cuts the Equinoctial in B ; ſo ſhall ♈ T be the Sun's Amplitude from the Eaſt or Weſt ; and ♈ B the aſcenſional Difference ; and both of them meaſured from the Center ♈ by a Line of $\frac{1}{2}$ Tangents ; but to determine their juſt Quantities by Calculation Logarithmetical, theſe are the Proportions, *viz.*

In the Right-angled ſpherical Triangle ♈ B T, Right-angled at B, is given the ∠T ♈ B, the Comp. of the Lat. and B T the Sun's Declination ; to find ♈ T, the Sun's Amplitude, and ♈ B, the aſcenſional Difference (by oppoſite Sides and Angles)

As

As S. of C. Lat. .. S ☉ Decl. :: R .. S. ☉ Ampl.
— S. 46° : 40′ — — S. 29° : 39′ — S. 90 — 27° : 32′.

That is, E. 27 : 32′ N. } which turn'd into
And W. 27° : 32′ N. }
Points of the Compaſs, gives neareſt,

E. N. E. ½ N. } at { Sun-riſing.
And W. N. W. ½ N. } { Sun-ſetting.

For, *Note*, If the Sun's Declination be northerly, the Amplitude is to the northward of the Eaſt, or Weſt at Sun-riſing or ſetting, if the Declination be ſoutherly, to the Southward;

As R .. T. Lat. :: T ☉ Decl. .. S ☉ Aſcen x.
— T. 45°. T. 43° : 20′ — T. 19° : 39′ — S. 19° : 41′

By the firſt of theſe Proportions may the Tables of Amplitude be calculated.

Prob. 9. The aſcentional Difference given, or found, as in the laſt Prob. to find the Time of the Sun's riſing or ſetting; with the length of the Day or Night.

Rule 1. If the Latitude and Declination be both North, or both South, the aſcenſional Difference added to 6 Hours gives the Time of Sun-ſetting, and ſubtracted therefrom, Sun-riſing. And contrary, if one be North, and the other South, the aſcenſional Difference added to 6 Hours gives the Time of Sun-riſing, and ſubtracted therefrom, the Time of Sun-ſetting.

Example 2.

Let the Latitude be 43° : 20′ N°. and Sun's Declination, 19° : 39′ N. and the aſcenſional Difference as in the laſt, Prob. 19° : 41′. Then,

5) 19

5) 19 : 41 (} Divide by the Ratio of 15. *viz.* 5 and 3.

3) 3 : 56 : 12″

Hours 1 : 18′ : 44″ ☉'s Aſcen. *r.* in Time.

Add 6 : 00 : 00 Hours.

Hours 7 : 18 : 44″ Time of Sun-ſetting.

Subt. is 4^{h} : 41 : 16″. Time of Sun-riſing.

☉ R. Doub. 4^{h} : 37 : 28 = Length of the Day.

☉ S. Doub. 9^{h} : 22 : 32 = Length of the Night.

Rule 2. Is becauſe the Hour of the Sun's ſetting, ſhews the Time elapſed between Noon and the End of the Day; and which is therefore equal to ½ the length of the Day. Therefore, if the Hour of Sun-ſetting be doubled, it gives the Length of the Day, or Number of Hours the Sun is viſible above the Horizon.

Again; becauſe the Hour of Sun-riſing ſhews the Time elapſed, between the time of the Sun's riſing and Mid-night; and which is therefore equal to ½ the length of the Night. If the Hour of Sun-riſing be doubled, it gives the length of of the Night.

By this Prob. may our Tables of the Sun's riſing or ſetting, and length of Day or Night be calculated.

Alſo in the foregoing Triangle ♈ B T, may the ſucceeding Problems, 10 and 11, be reſolved, *viz.*

Prob. 10. If the Sun's true Amplitude obſerved (at Sea) were 27° : 32′ N. and the Sun's Decl. 19° : 39′. N. alſo given, to find the Latitude of the Ship, or Place? The Proportions are,

As

As S. ⊙ Amp. .. ℞ : : S ⊙ Decl. .. S. of Co. Lat. — S. 27 : 32′ — S. 90 — S. 19° : 39 — S. — 46° : 40′.

Whoſe Comp. to 90° is the Lat. 43° : 20 North.

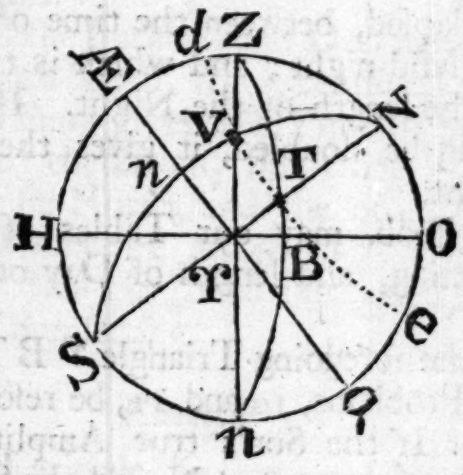
Prob. 11. If the Time of the Sun's riſing 4^h. 41′ : 16″, or ſetting 7^h 18′ : 44″, conſequently the aſcenſional Difference 19° : 41′, with the ⊙'s Decl. 19° : 39′ N. were given; to find the Lat. Then

As T ⊙ Decl. .. ℞ : : S. ⊙ Aſcen. ☩ .. T. Lat. — T. 19° : 39′ — S. 90 — S. 19° : 41′ — T. 43° : 20′ N.

Theſe Problems 10 and 11 may be of good Uſe to the Mariner, when he cannot have an Obſervation at Noon for the Lat. but by the Benefit of a clear Evening; having obtain'd the Sun's Amplitude (with allowance for Variation of the Compaſs) and the Declination, for the Time given; (or the true Time of the Sun's ſetting obſerv'd) he may, by the help of theſe, find the Lat.

Prob. 12. The Lat. of the Place, (ſuppoſe 35° 32′ N.) and the Sun's Declination (admit 23° : 30° N.) given; to find the Sun's Altitude (height) and Azimuth at the Hour of 6?

Projection.



1. Having deſcrib'd the Circle and quartered it, ſet off the Lat. and draw the Parallel of Declination, as directed in Prob. 8th and 5th. The Paral-

Parallel of Declination cuts the Axis N ♈ S in T. Then (2.) Draw through Z, the *Zenith* Point, the Point T, and the *Nadir*, *n*; an Azimuth Circle, Z T B *n*, it will form the Right-angled ſpherical Triangle, ♈ B T, Right-angled at B; the Axis N ♈ S is the 6 o' Clock Hour Circle; and B T is the Sun's Altitude, and ♈ B on the Horizon, the Sun's Azimuth, from Eaſt or Weſt at the Hour of 6. Each of which may be meaſur'd by Prob. 3.

Calculation Logarithmetic.

For the Sun's Altitude, 'twill be by the Rule of oppoſite Sides and Angles,

As ℞ .. S. ♈ Decl. ♈ T :: S. Lat. .. S. ⊙ Alt. at 6.
— S. 90 — S. 23° : 30′ —— S. 35° : 32′ — S. 13° : 24′.

For the Sun's Azimuth from the Eaſt or Weſt,

As T. C. ⊙ Decl. .. ℞ :: S. C. Lat. T. ⊙ Azim.
— T. 66° : 30′ —— S. 90° S. 54° : 28′ — 19° : 28′ Eaſt;

Northerly, if in the Morning; or Weſt-northerly, if in the Evening. Wherefore the Sun's Azimuth 19° : 28′ ſubtracted from 90°′. gives the Azim. from the N. 70° : 32 Eaſt, or near the E. N. E. ¼ E. in the Morning.

Again, the Sun's Azimuth 19° : 28′ found above, added to 90°. gives the Sun's Azimuth from the South 109° : 22′ towards the Eaſt, if it be in the Morning; but, if the Obſervation had been in the Evening, the Sun's Azimuth would have been W. N. W. ¼ W.

Note, If the Declination be contrary to the Lat. that is, if one be North, the other South; then, inſtead of the Altitude, before found, it gives the Depreſſion, and ſhews how many Degrees the Sun is below the Horizon at the Hour of 6.

Prob. 13.

Prob. 13. If the Triangle above, *viz.* ♈ B. T, were given the Sun's Altitude at the Hour of 6, (13° : 24′) and Declination (23° : 30′) to find the Latitude and Sun's Azimuth at the ſame time; then ſay by the Rule of Oppoſite Sides and Angles,

As S ☉ Decl. .. ℞ :: S. ☉ Height .. S. Lat.
—S. 23° : 30′—S. 90°—S. 13° : 24′—S. 35° : 32′ N.

Again,

As S. C. ☉ Alt. .. ℞ :: S. C. ☉ Decl. .. S. C. ☉ Az.
As S. 76° : 36′—S. 90°—S. 66° : 30′—S. C. 19° : 28′.

Whoſe Comp. to 90°. is the Sun's Azimuth from the Meridian, or North and South 70° : 32′.

Prob. 14. If the Altitude (13° : 24′) and Azim. (19° : 28′) were given, (in the aforeſaid Triangle) to find the Lat. and Sun's Declination.

Then 'twill be,

As T. ☉ Alt. .. ℞ :: S. ☉ Azim. .. T. C. Lat.
— T. 13° : 24′—S. 90°—S. 19° : 28′ — T. 54° : 28′

Whoſe Comp. to 90°. is the Lat. 35° : 32′ North.

Again;

As ℞ .. S. C. ☉ Alt :: S. C. ☉ Azim. .. S. C ☉ Dec.
—S. 90—S. 76° : 36—S. 70° : 32′——S. 66° : 30′.

Whoſe Comp. to 90 is the Decl. 23° : 30′ North.

Prob. 15. The Lat. of the Place; (ſuppoſe 35° : 32′ North) and the Sun's Declin. (as before 23° : 30′ N.) given; to find his Altitude, and the Time when he is due Eaſt or Weſt.

In the laſt Scheme to Prob. 12. having drawn the Circle, quarter'd it, and ſet off the Lat. drawn the Axis, N ♈ S; Equinoctial Æ Q, and the Parallel of the Declination, *d* T *e*, which cuts the prime Vertical, or firſt Azimuth, ♈ Z in V. then through N ♈ and S, draw the Meridian N V S, cutting the Equinoctial at Right-angles in the Point

n. So

n. So that in the Right-angled Triangle ♈ *n v*, will be given the ∠ U ♈ *n*, the Lat. and the Sun's Declinat. *n v*; to find the Sun's height, ♈ *v*, and Hour from 6, ♈ *n*; each of which is meaſur'd on the ½ Tangents; Logarithmetic. by the Rule of oppoſite Sides and Angles.

As S. Lat... S. ☉ Decl. :: ℟ .. S. ☉ Alt. E. or W.
—S. 35° : 32′ S. 23° : 32′ — S. 90— S. 43° : 19.——

Again;

As ℟ = T. C. Lat. :: T. ☉ Decl. .. S. hour from 6.
S. 90 — T. 54° : 25′ — T. 23° : 30′ S. 37° : 25′.

which reduced into Hours (is, 1ʰ 49′ : 4″) and ſhews how long after 6 in the Morning it is e'er the Sun be due Eaſt, and how long before 6 in the Evening the Sun comes to the Weſt. Wherefore

to 90°, or ——————	6ʰ	00′	00″
add the Time above ————	1	49	40
Sum is the Time the Sun is due Eaſt in the Morn. ——	7	49	40

Or,

	h	′	″
From 90° = —— ——	6	00	30
Subtract the ſaid Time ——	1	49	4
Rem. the Time the Sun is due Weſt in the Afternoon.	4	10	20

Note, If the Lat. and Declination given had been one North, and the other South, the Sun would be under the Horizon, and the Queſtion of no uſe.

Prob. 16. In the ſame Triangle ♈ *n v*. let there be given the Sun's Height (43 : 19) and Declination (23 ½ North) to find the Lat. and Hour of the Day? Then ſay, By the Rule of oppoſite Sides and Angles,

As S. ☉ Alt... ℟ :: S. ☉ Decl. .. S. Lat.
—S. 43° : 19′ — S. 90 — S. 23 : 30′ — S. 35° : 32′ N.

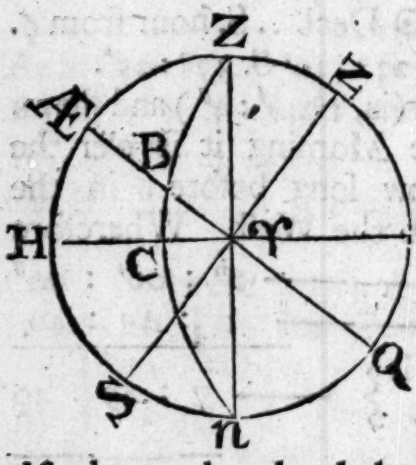
Again, for the Hour.

As S. C. ☉ Decl... ℟ :: S. C. ☉ Alt. .. S. C. Hour.

— S. 66° : 30′ — S. 90. — S. 46° : 41′ — S. 37 : 15′
Or, 1ʰ 49′ : 40″. from 6 : AM. or P. M.

Prob. 17. The Sun in the Equinoctial, the Lat. of the Place (ſuppoſe 51° ½ N.) and Hour of the Day, (admit 3ʰ ½ Afternoon, or 8ʰ ½ in the Morning, each of which are 3ʰ ½ diſtant from the Meridian or Noon) given, to find the Sun's Height and Azimuth.

Conſtruction.



1. 3 ʰ ½ from 6ʰ reſts 2 ʰ. ½ from 6 a Clock, (or the Center ♈) which reduced into Deg. and Min. is = 37° : 30′.

2. Then the Circle drawn, quarter'd, and *noted* with Z *n*, and H O, and the Axis N S, and Equinoctial E Q alſo drawn by the help of the Lat. 51° : 30′ N. (Æ repreſents Noon, and Q Midnight).

3. Make ♈ B = ½ Tang. 37° : 30′ the Hour from 6. Laſtly, deſcribe through the Points Z B *n*, the Azimuth Circle Z B C *n*. Then in the Right-angled Triangle, ♈ C B, Right-angled at C, is given the ∠ C ♈ B, the Comp. Lat. 38° : 30′, and Hour from 6. ♈ B 37° : 30′, to find the Sun's Altitude C B, and Azimuth ♈ C. Therefore it will be by Logar. pr. Rule oppoſite Sides and Angles,

As ℞ .. S. hor. from 6 :: S. C Lat. S. ⊙ Alt.
— S. 90 S. 37° : 30′ — S. 38° : 30′ — S. 22° : 10′.

And again,

As T. C. hor. .. ℞ :: S. Lat. .. T. ⊙ Azim.
— T. 52° 30′ — S. 90° — 51° : 30′ — T. 30° : 59′ which added to 90° = ♈ O, gives the Azimuth from the North, to be counted Eaſterly, if it be in the Morning;

Morning; but Weſterly, if it be in the Afternoon. But ſubtracted from 90° = ♈ H gives the Azimuth from the South, to be counted towards the Weſt, if it be in the Afternoon; but if it be in the Morning, towards the Eaſt.

Prob. 18. If in the ſame Triangle ♈CB, were given the Sun's Altitude, when he is on the Equinoctial (22°: 16′) and his Azimuth (30°: 59′ from the Eaſt or Weſt) to find the Hour of the Day, and Lat. of the Place?

The Proportions by Logar. are,

As T. ⊙ Alt. .. ℞ :: S. ⊙ Azim. T. Lat.
— T. 22°: 16′ — S. 90° S. 30°: 59′ T. 51°: 30′ N.

And,

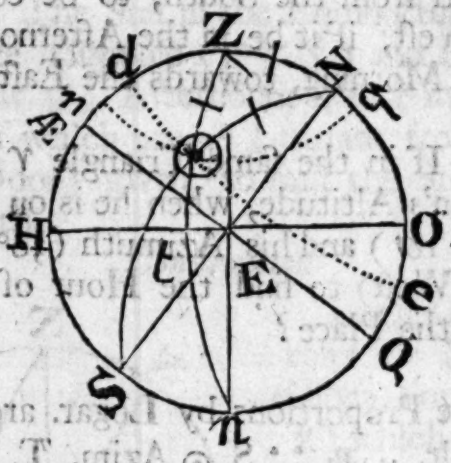
As ℞ .. S. C. ⊙ Alt. :: S. C. ⊙ Azim. .. S. C. hour.
— S. 90° S. 67°: 44′ —— S. 59°: 1′ — S. 37°: 30′

Whoſe Comp. to 90° is 52°: 30′. Or in Time 3ʰ. 30ᵐ from Noon. Therefore, if the Obſervation was made in the Morning, 'twas 8ʰ. 30′. if in the Afternoon, 3ʰ. 30ᵐ.

I might enlarge to a great number of Queſtions, in the application of a Right-angled ſpherical Triangle, to Aſtronomy, but I judge theſe ſufficient, with due Application, to the Mariner's Uſe, in finding the Lat. or Azimuth, Morning, or Evening, when he cannot get an Obſervation at Noon. I now come to ſhew how he may find the Sun's Azimuth at any time of the Day, (except at Noon, and when the Sun is riſing or ſetting).

Prob. 19. Given the Lat. of the Ship or Place, 51°: 30′ North, the Sun's Declination (23°: 30′ N.), and Altitude, or Height of the Sun (49°: 40′) To find the Sun's Azimuth from the North or South?

Projection.



1. The Circle being deſcrib'd and quarter'd with H *o*, and Z *n*. Alſo the Lat. 51°: 30′. ſet off the Axis N E S, and Equinoctial, Æ Q drawn.

2. Deſcribe the Parallel of the Declination, (with its Comp. 66°: 30′) after the ſame manner as was directed in Prob. 5, as *d e*.

3. After the ſame manner alſo, with the Comp. Alt. 40°: 20′. deſcribe the Parallel of Altitude *n n*, from Z, the Zenith, as you did the Parallel of Declination *d e*, from N. the North Pole; theſe two Parallels interſect each other in ⊙ the Place of the Sun.

4. Through N. ⊙ and S. deſcribe a Meridian Circle, as N. ⊙ S.

5. Alſo thro' the Points Z ⊙ and *n* draw an Azimuth Circle Z ⊙ *n*, and it's done; then in the Oblique Spherical Triangle N Z ⊙, is given the three Sides, *viz.* N Z = to Comp. Lat. 38°. 30′. N. ⊙ the Comp. Declination 66°. 30′. and Z ⊙ the Comp. of the Sun's Height = 40°. 20′. to find the Angle N Z ⊙, which is the Sun's Azimuth from the North Part of the Horizon O, and = to *t* O on the half Tangents, alſo H *t* is the Azimuth from the South Part of the Horizon H, and either

ther of them may be measured on the half Tangents. Thus E O = EH = half Tangent 90°. consequently HE + EO = 180°, therefore E *t* measured on the half Tangents and to 90°. = E O is = the Sun's Azimuth from the North, and E *t* measured on the half Tangents and taken from 90°. gives H *t* the Sun's Azimuth from the South. Or H *t* measured the backward way of the half Tangents from 90°. counting 80°. 10°. and 70°. 20°, &c. gives the Sun's Azimuth from the South as before.

But to determine the just Quantity of the Sun's Azimuth, from the North or South by a Logarithmetic Calculation, you must observe this Rule;

Add the Complements of your *Data* (given things) together, and find the Difference between their half Sum, and the Comp. of the Declination, if the Latitude and Declination are both North or both South; (but if the Latitude and Declination are one North the other South, take the half Sum from the Declination added to 90°.)

Then to the Arithm. Comp. of the Logarithms of the Sine of the Comp. of $\left\{\begin{matrix}\text{Lat.}\\\text{Alt.}\end{matrix}\right\}$ add the Logarithm Sines of the $\left\{\begin{matrix}\frac{1}{2}\text{ Sum}\\\text{Diff.}\end{matrix}\right\}$ afore found; half the Sum of those four Logarithms gives the Sine-Comp. of half the Sun's Azimuth; from the North in North Latitude, and from the South in South Latitude.

Operation.

		° ′	
To Comp.	Lat.	38 : 30 S. Co. Ar. —	0.205850
	Alt.	40 : 20 S. Co. Ar. —	0.188939
	Dec.	66 : 30	
	Sum =	145 : 40	
Add	½ Sum =	72 : 40 — S.	9.979815
	Co. De. =	6 : 10 = Diff. S.	9.031089
		Sum	19.405693
		½ Sum	9.702846.

° ′

Sin. Comp. = 59 : 42 (½ the Azim.

59 : 42

Sun's Azim. 119 : 24 from the North,
Subtract from 180 : 00

Sun's Azim. 60 : 36 from the South.

Which turn'd into Points of the Compaſs is 5¼ + 1°.32′. ſo that the Sun is { S.E. b. E. ¼ E. 1°.32′. E^ly. / S.W. b. W. ¼ W. 1°.32′ W^ly.

Or

If the Obſervation was made in the { Morning / Afternoon.

Note. The Comp. Arithmetic. of the two Log. Sines in this Example (or any other) is found by ſubtracting each Figure in the Tables from ſo many Nines, (or 9,999999) and ſetting down the Remainders.

Exam. 2. In the Lat. 51°. 30′. S. the Sun's Declin. 23°. 30′. S°. and his Altitude 49°. 40′. given to find his Azimuth from the South?

The

The Operation is the ſame with the firſt Example, only as the Azimuth there was accounted from the North, this finds it from the South Part of the Horizon, 119°. 24′. Which taken from 180°. remains 60°. 30′. from the N. ſo that the Sun would then be N. E. b. E. 3°, 15′. Eaſt A. M. or Morning, and N. W. b. W. 3°. 15′. W. if P. M. or Evening.

Exam. 3. In the Lat. 51°. 30′. N. the Sun's Declination 13°. 30′. S. and his Alt. 19°. 40′. what is the Sun's Azimuth from the South?

Operation,

To. Co.	Lat. —— 38 : 30	S. Co. Ar.	0.205850
	Alt. —— 70 : 20	S. Co. Ar.	0.026102
⊙, Diſt. from N. Pole	103 : 30		
	Z = 212 : 20		
Add ½ Z	= 106 : 10	S.	9.982477
	Diff. 2 : 40	S.	8.667689
		Z	18.882118
S. C. is	73 : 58	½ Z	9.441059

Doubled is 147°. 56′. ⊙ Azimuth from the N. And the ⊙ Azimuth from the North ſubtracted from 180°. gives 32°. 04′. the ⊙ Azimuth from the South Eaſterly in the Morning, or South Weſterly Afternoon; which is S. S. E. 9°. 34′. E. A. M. or S. S. W. 9°. 34′. W. P. M.

Exam. 4. In the Lat. 51°. 30′. S. the ⊙ Declin. 13°. 30′. N. and his Alt. 19°. 40′. what is the ⊙'s Azimuth?

Add the Declination to 90°. and it's 103°. 30′. the Sun's Diſtance from the South Pole, then work as in the third Example, and you'll have the Sun's Azimuth from the South 147°. 56′. (as before) which ſubtract from 180°. leaves the Sun's Azimuth from the North Eaſtward 32°. 04′. or N. N. E. 9°. 34′. Eaſt in the Morning, and N. N. W. 9°. 34′. W. if the Obſervation had been in the Afternoon.

Theſe are all the Varieties that can happen in finding the Sun's Azimuth.

Likewiſe the Sun's Azimuth may be found Logarithmetic. at two Operations thus: Let it be as in the firſt Example, *viz.* Latitude 51°. 30′. ⊙'s Declination 23°. 30′. North, Alt. 49°. 40′. to find the Sun's Azimuth, having made the ſame Preparation, as in the foregoing Examples, and found the Comp. Lat. 38°. ½ Comp. Alt. 40°. 20′. the Comp. Declin. 66°. 30′. the half Sum 72°. 40′. and Diff. 6°. 10′. Then ſay,

As R .. S. C. Lat :: S. C. Alt. .. a 4th Sine
—S. 90—S. 38°. 30′.——S. 40°. 20′——S. 23°. 46′.

Again,

As 4th S. .. S. ½ Sum :: Diff. .. a 7th Sine.
—S. 23°. 46′.—S. 72°. 40′.—S. 6°. 10′—S. 14°. 45′.

Whoſe Logarithm is	9.40569
To which add Radius	10.0000
Sum is	19.40569
½ Sum	9.70284

	°	′
S. C. is	59	: 42
Doubled	59	: 42

Sum 119 : 24 is the Sun's Azimuth from the North as in the firſt Example before found.

In-

Instrumental by Gunter's *Scale thus,*

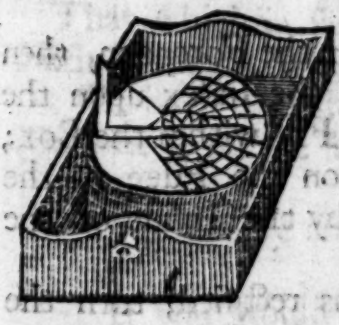
The Ext. } from { R.S. 90°. to S. C. Lat. 38°. ½ on Sines
reaches } { S. C. Alt. 40°. 20′. to a 4th Sine 23°. 46′. on the Sines.

The Ext. } from { 4th S. 23°. 46′. to S. ½ Z. 72°. 40′. on Sines
reaches } { Diff. 6. 10′. to S. 14°. 45′. on the Sines, against which underneath on the versed Sines, stands 119°. 24′. the Sun's Azimuth from the North as above.

Having shewn how to work an Amplitude or an Azimuth in the preceding Problems, (which we call the Sun's true Amplitude or Azimuth, to distinguish it from the Magnetical, or that obtain'd by an Azimuth Compass, that has Variation; proceed we therefore to shew the Use of the Sun's Amplitude Compass, and thereby with the Sun's true Amplitude or Azimuth, (found by Calculation) to find the Variation of the Mariner's Compass.

1. *The Use of the* Azimuth *Compass.*

THIS Compass differs from the Meridian or common Compass, in these few necessary Appendants or Things, *viz.* upon the round Box, wherein are the Fly and Needle, is fastened a broad Circle of Brass, the half of the Limb thereof is divided into 90°. numbred from the Middle of the said Divisions both ways, with 10, 20, 30, *&c.* unto 45°. which Degrees are also subdivided into Minutes by Diagonal Lines, and by certain Excentrick Circles intersecting one another; for



these

these Degrees are drawn from the opposite Part of the Limb whereon the Index moveth, cutting those Degrees. On this Index is erected a Sight, which for Conveniency is to fall down with a Hinge, and set up upon Occasion; and from the Top of this Sight, down to the Middle of the Index, is fastened a Thread or Lute-string, to shew the Shadow of the Sun, upon a Line that is on the Middle of the said Index.

And by this Means of placing the Index upon the Circumference, the Degrees come to be as large again as they would be, if it moved upon the Center, by *Euclid. Lib.* 3. *Prop.* 20.

This broad Circle is crossed at right Angles with two Strings, and commonly from the Terminations of these Strings are drawn four small black Lines on the Inside of the Box, for rectifying the Instrument in time of Observation, by the four Lines that are also drawn at right Angles, on the Superficies of the Fly.

This Compass, being thus fitted, is hung in strong Brass Rings, and those also fastened into a square Wainscot Box fitted for that Purpose. See the annexed Figure thereof.

1. To observe with this Instrument, do thus for an Azimuth; rectify the Brass Limb on the Edge of the Box (by the Needle and Fly within the Box) according as the Nature of the Observation doth require.

For if the Observation be in the Forenoon, then you must put the Center of the Index upon the West Point of the Chard or Fly within the Box; and so that the four Lines on the Edge of the Chard, and the four Lines by the Inside of the Box, do always concur.

The Instrument being thus rectified, turn the Index towards the Sun, until the Shadow of the Hipothenusal Thread fall directly into the very

ry Sight that is on the Index, and alſo upon a Line that is in the middle of the Index; then at the ſame time will the inner Edge of the Index cut the Degree and Minute of the Sun's Magnetical (or Compaſs) Azimuth from the Eaſt to the Northward or Southward; as for

Example, Suppoſe the Inſtrument be rectified, as before is ſhewn for an Obſervation in the Forenoon; and that the Index ſhould cut 10°. upon the Limb to the Northward of the Eaſt; then is the Azimuth of the Sun 80°. from the North, or elſe 100°. from the South. So likewiſe if the Index had cut 10°. to the Southwards of the Eaſt, then would the Azimuth be 80°. from the South, and 10°. from the North.

N. B. That the Compaſs ſtanding in this Poſition; and if the Azimuth of the Sun be leſs than 45 deg. from the Meridian, and you turn the Index towards the Sun, it will go off the Diviſions on the Limb, and there can be no Uſe made thereof as it now ſtands.

Therefore you muſt turn the Inſtrument, juſt one Quadrant or Quarter of the Compaſs, *viz.* place the Center of the Index on the North or South Point of the Chard, according to the Sun's Poſition from you, and then the Edge thereof will cut the Degree of the Sun's Azimuth from the North or South.

That which is ſaid as to the Uſe of the Azimuth Compaſs, when the Sun is on the Eaſt Side; the like is to be underſtood with the ſame Reaſon, when he is on the Weſt Side of the Horizon.

2. To obſerve an Amplitude by the *Azimuth Compaſs*.

1. If you would take it in a Morning at Sun-Riſing, turn the Center of the Index right over the Weſt Point of the Fly, and rectify the Inſtrument

ment by the Lines within the Box, to Lines on the Fly.

Then looking through the Sight, turn the Index towards the Sun, until you cut the Body of the Sun with the Thread; at the ſame time will the edge of the Index ſhew the Degree of the magnetical Amplitude, upon the graduated Limb, from the Eaſt, either Northerly, or Southerly.

2. But if you take the Amplitude in the Evening at Sun-ſetting, then you muſt put the Center of the Index over the Point of the Fly, and proceed as before.

Cautions to be obſerv'd in taking the magnetical Azimuth and Amplitude.

1. 'Tis beſt to take the Azimuth when the Sun is not very high above the Horizon, becauſe the Motion of the Sun is then more eaſily obſerved.

2. Becauſe of the Refraction of the Vapours near the Horizon, which cauſeth the Sun to appear in the Horizon, when indeed he is about 30 Minutes below it; therefore, when you obſerve for the Amplitude, let the Center of the Sun be about 30^m or near ½ his apparent Diameter 32^m above the Horizon.

3. When you obſerve for the Azimuth, at that Inſtant to obſerve the Sun's Altitude with a Foreſtaff, Quadrant, or *Almicanter* Staff, (whoſe Uſe ſhall be ſhewn a little farther.

4. To find at that Inſtant of Time you obſerve for the Azimuth or Amplitude exactly the Sun's Declin. and Lat. the Ship is in: As for Example.

Admit at Sea, *September* the 9th, 1724, my Ship was yeſterday Noon in the Lat. of 45°: 30′ North *per* Account, the Sun's Declination was then, 1°: 25′ N. but having run South-weſterly till this Morning 6 o' Clock, and made 45^m Southing, I would know the Lat. of the Ship, and Sun's Declination, for that time? 45°: 30′—0: 55 is =

44°: 45′

44° : 45′ N. the Lat. of the Ship;

Sept. the 8th } Sun's Declin. is { 1 : 25′ } N.
9th } { 1 : 02 }

Diff. is the Diurnal Decreaſe of Declination, 0 : 23

Then ſay,

hor. m. ho. m.

If 24 give 23, what 18, Time? Facit 17 which ſubtracted from 1° : 25′, the Sun's Declination North decreaſing, gives 1° : 08′ North, the Sun's Declination for the Hour given; (which is near upon the time of Sun-riſing).

After the ſame manner, you may find the Lat. and Declination for any Hour from Noon, or at the Time you would obſerve for the Azimuth.

3. *To find the Variation of the Compaſs, having the Sun's true Amplitude or Azimuth, obtain'd by* Prob. *8th and 9th of Aſtronomy foregoing; and alſo the Magnetical Amplitude or Azimuth, gain'd by the Azimuth, Compaſs, and preceding Rules.*

Definition.

The finding out the admirable Virtue of the *Loadſtone* on a Needle touch'd thereon, doth point to a meridional Poſition, was the greateſt Advantage to Navigation that ever happened; yet in this uſeful *Arcanum* there is this Defect (from ſecret Cauſes I have not room here to ſpeak of) that the Needle, tho well touch'd in the Mariner's Compaſs by the Magnet, yet admits of ſeveral Variations in different Places, Eaſterly or Weſterly, more or leſs, to above 30° Degrees, which the Mariner ſhould carefully obſerve at all

Sea-

Seaſons, or he may bring his ſhip to he knows not where.

Therefore to proceed:

The Variation of the Compaſs, in plain Terms, is nothing elſe but the Difference Eaſterly, or Weſterly; that the North Point of the Sea Compaſs declines, or varies from the true (North, or) Meridian of the (terraqueous Globe or) World; and may be found by the following Rules and Examples.

Rule 1.

When the Compaſs, Amplitude, or Azimuth, and the Sun's true Amplitude, or

Azimuth, are { the / not the } ſame,

There's no / Their Difference is the } Variation.

Rule 2.

For the Quantity of Variation,

Amplitudes, or / Azimuths } of { one / Diff. } Kind;

Their { Diff. / Sum } is the Variation.

If the Sum exceed 90°, ſubtract it from 180°.

Rule 3.

For the Quality of the Variation.

If true Ampl. or / Azim. be to the { Right / Left } of the magnetical,

The Variation is { Eaſt. / Weſt.

Examp. 1. Being at Sea *Sept.* the 9th, 1724, in the Lat. of 44° : 45′ N. the Sun's Declination 1° : 08′ N. by Calculation, the Sun's Amplitude

was 01° 35′ East-northerly; but obſerving by the Azimuth Compaſs at Sun-riſing, found the Magnet. Ampl. E. 10° : 50′ N, I demand the Variation?

1. *Geometrical.*

Conſtruct. 1. Deſcribe a Circle with a Chord of 60°. quarter it, and *note* it with N. North, S. South, W. Weſt, E. the East Points of the true Horizon.

2. Make E ⊙ = Chord of the Sun's true, and E *m*, the magnetick Amplitude, ſo ſhall ⊙ *m* on the Chords be = 9° : 15′, the Variation in Quantity.

3. Extend your Compaſſes from *m*, the magnetical Amplitude (or Azim.) to N, the true North; that Extent ſhall reach (on the Circle) from the Sun's true Amplitude (or Azim.) ⊙ to the falſe or Compaſs North N, ♓ = ⊙ *m* = 9° 15′ Eaſterly.

2. *Arithmetical.*

From the Sun's magnetick Amp. E 10° : 50′ N.
Take the Sun's true Amplitude E. 01 : 35 N.

Remains the Variation —— N. 09 : 15 Eaſterly.

Examp. 2. At Sun-ſetting, in the ſame Scheme, let the magnetick Amplitude be W. 10° : 50′ N.
And Sun's true Amplitude —— W. 01 : 35 N.

Their Difference is the Variation N. 09 : 15 Weſterly.

Examp.

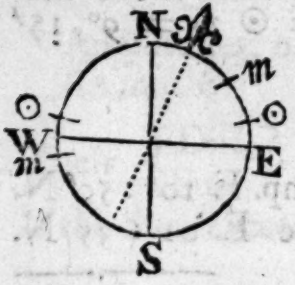
Examp. 3. At Sun-riſing, let the Sun's Amplitude be Eaſt 10°: 10′ North, and by the Azimuth Compaſs Eaſt 10°: 10′ South: What's the Quantity and Quality of the Variation?

To the Sun's Amp. E.	10°: 10′ N.
Add the magnet. E.	10 : 10 S.
Sum is the Var. W.	20 : 20

Examp. 4. Let the Sun's Azim. in the Mo. be N. 79°: 50′ E.
And the magnet. S. 79 : 50 E.

Sum	159 : 40
Subtract from N E S =	180 : 00
Remains the Variation Weſt	20 : 20

as in the Scheme above. Obſerve, that the Azimuths are accounted from the North and South, Eaſterly, or Weſterly; as the Amplitudes were counted from the Eaſt or Weſt, northerly, or Southerly.



Examp. 5. At Sun-ſetting, let the Sun's Ampl. be W. 10°: 10′ N.
and the mag. Amp. W. 10°: 10′ S.
What's the Variation?

Sun's Amplit. W.	10°: 10′ N.
Magnetical. W.	10 : 10 S.
Their Sum is the Variat.	20 : 20 Eaſterly.

Example. 6. in the ſame Scheme.
The Sun's Azim. in the Even. N. 79°: 50′ W.
Magnetical Azim. —— S. 79 : 50 W.

Sum	159 : 40
Subtract from	180 : 00
Variation Eaſterly	20 : 20

Exam.

Examp. 7. In the ſame Scheme.

The Sun's Azim. in the Morn.	N.	79° : 50′ E.
Magnetical	N.	59 : 30 E.
Diff. is the Variation Eaſterly,		20 : 20

Examp. 8. The Sun in the Equinoctial riſes Eaſt, and ſets Weſt in all Parts of the World, (which is about the 10th of *March*, and 12th of *September*) at which time you obſerve by your magnetical Compaſs, he riſes Eaſt by South. What is the Variation?

The Sun being at E, in the Eaſt Point of the Horizon, and the magnetick Amplitude at *m*, E. by S. by *Conſtruction* the 1ſt. the falſe North of the Compaſs will be found one Point to the Weſtward of the true North N. So that the Variation is 1 Point, or 11°: 15′ Weſt.

Again; the Sun in the Equinoctial riſes E. by N. the Variation is 1 Point Eaſterly. If he ſets W. by N. the Variation is 1 Point Weſterly: If W. by S. 1 Point Eaſterly; as will plainly appear, if you project by the former Rules.

There are other Methods of finding the Variation of the Compaſs, but I ſhall briefly mention but theſe three following, *viz.*

1. To find the Variation by the North Star.

1. The beſt Time for this is, when the North Star is upon the Meridian, above or under the Pole; which may be known thus;

When the Guards or Pointers of the Great Bear are right under the North Star, it is upon the Meridian,

ridian, above the Pole; but when the ſaid Pointers are right over the North Star, it's upon the Meridian, under the Pole; and this is eaſily known by holding up a Thread and Plumet exactly between your Zenith and the North Star; the Thread will cut the two Stars call'd the Pointers.

2. Then to find the Variation with your Azimuth Compaſs; look through the Sight and turn the Index towards the North-Star, until you cut that Star with the Thread, and at the ſame time the Edge of the Index will ſhew you the true North; and as many Degrees as you find the Index on the Eaſt-ſide of the *Flower-de-luce*, or North Point of your Compaſs, ſo many Deg. is the Variation Weſterly; or as many Deg. as the Index is diſtant from the *Flower-de-luce* Weſtward, ſo many Degrees is the Variation Eaſterly: This is ſo plain, it needs no Example.

4. To find the Variation at Noon, by the Shadow of the Sun.

1. When by your Obſervation, you find the Sun on the Meridian, that is, at 12 at Noon, your Compaſs Index being turned towards the Sun, if the Shadow of the Thread fall upon the Line on the Index, and the Index alſo falls exactly upon the North and South Line, then is there no Variation; but if it falls a-ſide of it, the Variation is as many Degrees as the Index is diſtant from the ſaid North and South Line.

2. To find what Side the Variation is on.

If the Index falls on the Eaſt-ſide of the North, the Variation is Weſterly; but if on the Weſt-ſide, then the Variation is Eaſterly; for if the Beam of the Sun, and the Shadow of the ſame Beam, make but one and the ſame Right-line, it's plain, that the Sun being exactly South, his Shadow will be exactly North. But *Note*, That the Hour of 12, or Meridian Altitude of the Sun is known

at

at Sea only by the greateſt Altitude of the Sun that Day above the Horizon; and this might practically cauſe ſome Error, becauſe about Noon, it's known by Experience, that one cannot for ſome time perceive that the Sun riſes or falls, or be ſenſible that he changes Place, altho' it is certain he doth. Wherefore to obſerve more exactly, you are to mind how much the Shadow, all the time that the Sun ſeems to ſtand, changes Place upon your Compaſs, and to take the Middle betwixt the two Extremes, for the true meridional Line (or North and South) and truſt to the Variation that it marks.

This alſo is ſo eaſy, that it needs no Example.

5. To find the Variation by two equal Altitudes of the Sun, taken before and after Noon.

1. With a Quadrant or Fore-ſtaff, obſerve the Sun's Altitude, and the Point of the Compaſs he is on at that moment of Time, *viz.* About the Hours of 8, 9, 10, or 11, in the Forenoon.

2. Obſerve the Point of the Compaſs the Sun is upon, when he has the ſame Altitude, (by your Quadrant or Foreſtaff) in the Afternoon, that you *noted* down in the Morning, (which will be about the ſame Hours diſtant from 12 o' Clock, *viz.* 2, 3, or 4 o' Clock Afternoon: Then, from theſe two Obſervations, may the Quality and Quantity of the Variation be found thus;

If theſe Points of the Compaſs be equally diſtant from the South Point of the Compaſs, then there is no Variation.

2. But if the Point in the Forenoon be farther diſtant from the South Point of the Compaſs, than the Point in the Afternoon, the Variation is Weſterly.

3. If the Point in the Forenoon be leſs diſtant from the South Point of the Compaſs, than the

Point in the Afternoon, then is the Variation Eaſterly.

For the Quantity of the Variation.

Take the intercepted Arches between the South Point of the Compaſs and theſe two Points, the one in the Forenoon, and the other in the Afternoon, found by Obſervation, the leſſer of theſe two Arches being ſubtracted from the greater $\frac{1}{2}$, the Remainder is the Variation of the Compaſs required.

Example.

Suppoſe in the Forenoon at 9 o' Clock, I ſet the Sun by the (Azimuth) Compaſs and find the Sun bears E. S E. and the Altitude 40°, and again in the Afternoon, about 3 o' Clock, I obſerve again the Point of the Compaſs the Sun is on when he hath the ſame Altitude (of 40°) which let us ſuppoſe is S. W. Then, in the laſt Scheme, let the Forenoon Point be *m*, and the Afternoon Point *a*, to find the Variation.

From S *m*, E S E, 6 Points, —	= 67° : 30′
Take S *a*, S. W. 4 Points, —	= 45 : 00
The Diff. is 2 Points —	= 22 : 30
$\frac{1}{2}$ the Diff. is 1 Point —	= 11 : 15

The Variation Weſterly; becauſe the Forenoon is farther from the South than the Point in the Afternoon. Or thus;

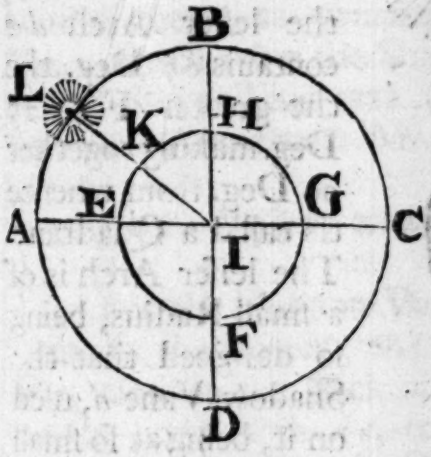
The Diſt. between the E S E and S. W. is 10 Points, the $\frac{1}{2}$ of which is 5 Points; which reckon'd from the E. S. E. towards the S. W. it falls upon the S. by E. the Magnetical, or Compaſs South; which is 1 Point to the Eaſtward of the true South: Therefore the Magnetical, or Compaſs North, is Weſtward from the true North 1 Point Weſterly, being the oppoſite Point thereto.

Thus

Thus have we exhibited five Methods of finding the Magnetical Variation at Sea. I proceed now to ſpeak of Cœleſtial Obſervations by Inſtruments.

Definition. A Cœleſtial Obſervation is founded on theſe two Principles, *Viz.*

I. That when many Circles are Concentric; that is, when many Circles are drawn from one and the ſame Center, but of different Diameters, Lines drawn from their Center to their ſeveral Circumferences, divide each Circle in the ſame manner and Proportion.



As the Circles A B C D, E F G H, being deſcribed from the ſame Center I E A, and I K L drawn; the Arches E K, or K H, ſhall have the ſame Proportion to the Circumference E F G H, as the Arches A L, or L B, have to the Circumference A B C D.

2. That the terraqueous Globe, or Maſs of Earth and Water we live on, compar'd with the the large Sphere of the Sun, is of no ſenſible Quantity, but only as a Prick, or meer Point, in reſpect thereof; therefore any Point on the Earth's Surface may be taken for the Center of the Sun, or Heavens; and by Conſequence, the Center of every Inſtrument may be accounted alſo the Center of the Sun, or Heavens.

The Uſe of the Sea Quadrant.

THIS Inſtrument was invented by Captain *Davis*, and thence called *Davis's Quadrant*; and by the *French*, the *Engliſh Quadrant*: It's at preſent the moſt general approved Inſtrument at Sea for obſerving the Sun's Meridian Altitude, or its Complement, the Zenith, Diſt. by the Noon Shadow of the Sun.

You ſee in the annexed Figure it conſiſts of two Arches; the leſſer Arch *d e* contains 65 Deg. the the greater F *g*, 25 Deg. making together 90 Deg. from whence tis call'd a Quadrant. The leſſer Arch is of a ſmall Radius, being ſo deſigned that the Shadow-Vane *d*, uſed on it, being at ſo ſmall Diſtance from the Horizon-Vane A, on which its Shadow (in Time of Obſervation) is to fall, might be more viſible to the Eye of the Obſerver. The greater Arch F *g* is of a large (generally three times the) Radius, that it might contain the leſſer Diviſions of a Deg. and being of a competent Breadth, thereon are uſually deſcrib'd 10 concentrick Circles, interſected with 3 or 6 Diagonal Lines in each Degree, making each Interſection 2 or 1 Minute. The Horizon-Vane A reſpects the Horizon; that at *d*, which gives the Shadow, is called the

the Shade-Vane; and that, through which you are to look for both Shadow and Horizon, is termed the Sight-Vane; as C.

Note, Of late there are two Shade-Vanes; one in which is fixed a Lens or double Convex-Glaſs, which contracts the Sun's Rays and caſts them into a ſmall bright Spot on a little black Spot on the Horizon-Vane, which has much improv'd the Inſtrument, if the Glaſs be well and truly fix'd; for with this it may be uſed in hazy Weather, alſo in clear Weather the Spot is more refined and conſpicuous than the Shadow, which at beſt is not terminated. Alſo, when you uſe this Vane you have no need to allow 16 Minutes, the Sun's apparent Semi-diameter, as you ought in the other Shade-Vane, which takes the Shade from the upper Limb of the Sun: This was the Contrivance of that ingenious Aſtronomer Mr. *Flamſted.*

To Obſerve with this Quadrant.

1. Put the Horizon Vane on the End at A, and home to the Center; the Sight-Vane on the Arch F *g*, cloſe to the Back of it, and the Shade-Vane on the little Arch *d e*, to a Number of Degrees leſs than you judge the Zenith Diſt. by 15 or 20 Degrees.

2. The Vanes thus fixed, turning your Back towards the Sun, the End CF in your Hand, look through the Sight-Vane, cauſing the upper Edge of the Shadow of the Shade-Vane to lie upon the upper Edge of the Slit in the Horizon-Vane, (or, if you uſe the Glaſs-Vane, bring the bright Spot on the black Spot on the Horizon-Vane) at the ſame time, if the Horizon appear through the ſaid Slit in the Horizon-Vane, the Vanes of the Quadrant ſtand at the Sun's preſent Zenith Diſtance.

3. But if the Sky appear inſtead of the Horizon, ſlide the Sight-Vane a little higher towards *g*: On the contrary, if the Sea appear inſtead of the Horizon, then ſlide the Sight-Vane lower towards F; continue ſo to do till the Horizon appear thro' the Horizon-Vane.

4. Continue obſerving a little before Noon, and as the Sun riſes higher, the Sea will appear thro' the Horizon-Vane, and the Sight-Vane muſt be ſlid lower accordingly, obſerving as often as may be convenient, till the Sun is at the higheſt, and then he will ſeem to ſtand.

5. When the Sun is paſt the Meridian, he begins to deſcend, or fall, and the Sky will appear thro' the Horizon-Vane inſtead of the Horizon: Then deſiſt obſerving for that Day.

6. Having thus done, add the Degrees the upper Edge of the Shade-Vane ſtandeth at, to the Degrees and Minutes cut by the Inſide of the Sight-Vane, their Sum is the Complement of the Sun's Meridian Altitude, or Zenith Diſtance; which with the Sum or Diff. of the Sun's Declination for that Day, you may find the Height of the Pole or Latitude, as ſhall be ſhewn a little farther.

Of the Almacantar Staff *made of Box or Pear-Tree: With an Arch of* 15 *Degrees curiouſly divided; and with* 3 *Vanes, as a Quadrant is, to take an Obſervation of the Sun, a little after Sun-riſing or ſetting, in order to find the Sun's Azimuth, and conſequently the Variation of the Compaſs.*

See the Figure prefixed; its Uſe is very plain to them that can obſerve with the Sea Quadrant.

The Deſcription and Uſe of the Fore-Staff and Croſs-Staff.

The *Fore-ſtaff* is ſo called from the Poſture of the Obſerver in uſing it, whoſe Face is towards the (Sun, or) Star generally: Tho' for the Sun it's ſo contrived (for preſerving the Eye) to be uſed backward. It's called alſo a *Croſs-Staff*, from its Form; being a ſquare Staff with three or four Pieces of Wood a-croſs it, which are called Croſſes: The Staff is uſually 2 ½ or 3 Foot long, and more than ½ Inch ſquare, having four Sides, each graduated like a Scale of Tangents: To each of them belong a diſtinct Croſs, with that of the Horizon Vane or Ten-Croſs; the others are the 30. 60, and 90 Croſs, and are thus to be underſtood: The

		Deg.			Deg.
10	Croſs belongs	3			10
30	to that Side	10	and ending at		30
60	beginning	20			60
90	at	20			90

The Uſe of the Fore-ſtaff, in taking the Sun's or Stars Meridian Altitude, or Zenith Diſtance.

1. Obſerve the 10. 30. 60. and 90 Croſs is to be uſed according as you judge the Meridian Altitude is more or leſs; that is, if leſs than 10, uſe the 10 Croſs: If between 10° and 30°, uſe the 30 Croſs: If between 30 and 60, the 60 Croſs: If more than 60, uſe the 90 Croſs.

2. Put

2. Put on the Croſs ſuitable to your Obſervation, the flat Side of it towards the flat End of the Staff. Then,

3. Hold the flat End of the Staff (as A) to the corner of your Eye; there let it reſt upon your Eye-bone, as near the corner of your Eye as you can, ſo it doth not hinder your Sight.

4. Then look at the upper End of the Croſs, (as at C) for the Sun, or Star; and at the lower End of the Croſs, (as at B) for the Horizon.

5. If at the lower End of the Croſs, you ſee all the Sky and no Water; then draw the Croſs a little nearer to your Eye.

6. If on the contrary, you ſee all Water and no Sky, then ſlide the Croſs a little farther from you.

7. Then if you ſee the Center of the Sun or Star, at the upper End of the Croſs, and the Horizon at the lower End, then the Croſs ſtands as it ought.

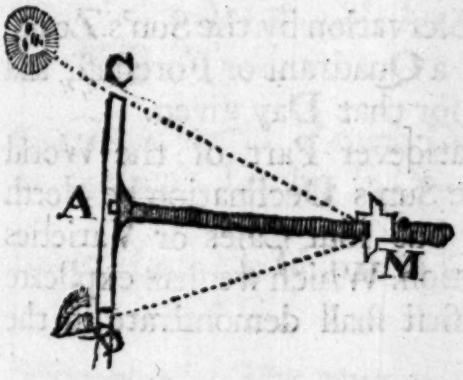
8. Wait till the Sun or Star be on the Meridian, making Obſervation often; and as the Sun or Star riſeth, draw the Croſs a little nearer your Eye.

9. If the Sun or Star be fallen, you will not ſee the Horizon (for the Water will hide it from you) and then your Obſervation is over at that time: Stir not the Croſs out of its Place; only ſee at what Degree and Minute it reſteth at, on that Side of the Staff belonging to the Croſs; and its the Altitude or Complement thereof, *viz.* The Zenith Diſt. according to the Word Alt. or Comp. on the Staff. Thus for a forward Obſervation. But what is more uſual and convenient is a backward Obſervation with the Foreſtaff, which is of Uſe only with the Sun; and for this purpoſe the 10 Croſs hath another piece of Wood or Ivory put croſs it; ſo that the lower Edge of this croſs Piece lieth even with the middle of the ſquare Hole in the 10 Croſs, which alſo anſwers to the middle

middle of the Thickneſs of the Staff. There is alſo a Shoe, or Plate of Braſs or Tin, with a Hole or Slit in it, and ſo fitted, that it will ſlide off and fit the Ends of the 90 60, or 30 Croſs: Theſe two Things prefix'd to a Fore-ſtaff make it fit for a Backward Obſervation of the Sun, which is thus;

1. As before directed, according as you judge the Sun's Meridian Altitude is more or leſs, ſo uſe the 90°, 60°. or 30° Croſs; putting it on the Staff, the flat Side of it even with the flat End of the Staff, there ſcrew it faſt, and at the End of the Croſs ſlip on the aforeſaid Braſs Shoe, ſo as to leave a Slit Sight through it, near the lower End of the Croſs.

2. Put the Ten Croſs (or Horizon Vane) on the Staff, the flat Side of it toward the other Croſs at the Staff's End, and the croſs Piece uppermoſt.



3. Turn your back to the Sun, look through the Slit in the Braſs Shoe, at the lower End of the Croſs, for the Shadow of the upper End of it, lying on the Ten Croſs, in the Line anſwering the middle of the Staff, and on each Side of the Staff.

4. At the ſame Time, the Horizon ſhould be ſeen (through the aforeſaid Slit) to lie even with the Shadow on the middle Line in the Ten Croſs, and at each End of it, on both Sides the Croſs.

5. But if inſtead of the Horizon you ſee only Water there, then draw the Ten Croſs nearer, till the Shadow and Horizon agree or meet in the ſaid middle Line.

6. On

6. On the contrary, looking as before, inſtead of the Horizon you ſee the Sky meet the Shadow, on the middle Line; then put the Ten Croſs from you till you you ſee the Horizon together meet at the middle Line.

7. Continue obſerving till the Sun be at the higheſt, and as the Sun riſeth, you muſt draw the Ten-Croſs nearer, in order to keep the Horizon and Shadow together on the middle Line of it.

8. If the Sun be fallen (after you have continued obſerving as before directed) the Horizon will lie below the Shadow on the middle Line, then is the Obſervation finiſh'd at that Time: Stir not the Ten Croſs out of its Place; for where it now ſtands, (on that Side of the Staff belonging to the Croſs, at the End of it) is the Sun's Meridian Altitude, or its Complement the Zenith Diſtance, as before in obſerving forward. Next to

§. 7. Work an Obſervation by the Sun's Zenith Diſtance, taken with a Quadrant or Foreſtaff, and the Sun's Declination for that Day given.

Definition. In whatſoever Part of the World you be, or whether the Sun's Declination be North or South; there are but four Caſes or Varieties in working an Obſervation. Which we ſhall explicate in their Order; but firſt ſhall demonſtrate in the annexed Scheme.

The Latitude of a Place is the Diſtance between the Zenith and Equinoctial; that is NO = ZE. The Sun's Declination is the Sun's Diſtance from the Equinoctial, either to the Northward or Southward of it, and the Sun's Diſtance from the Zenith of the Place, is his Diſtance from your Vertical Point in that Place to the North-

Northward or Southward of it. Now if from Z ⊙ the Sun's Zenith Distance, you subtract E ⊙ the Sun's Declination, there remains Z E = O N the Height of the Pole, or Latitude of the Place of Observation. Therefore.

Variety 1. Is, when the Sun is between the Equinoctial and Horizon, and then the Rule is as above; subtract the Declination from the Zenith Distance, the Remainder is the Latitude of the Place, contrary to the Declination.

Examples in North Latitude.

Admit at Sea *October* 30th by Observation, (with a Quadrant or Forestaff) I find the Sun to be distant from my Zenith 65°. 15′. towards the South, the Sun's Declination for the Day, (found by Calculation in *Prob.* 3. *Astronom. Problems*, or by our Tables) 17°. 08′. South. What Latitude is the Ship in?

	°	′	
From Sun's merid. Zenith Dist. Z ⊙	65	15	S.
Subt. the Sun's Declin. E O	17	08	S.
Remains Lat. the Ship is in	47	07	N.

Example 2. The Ship in South Latitude.

	°	′	
Let the Zenith Dist. be	56	12	N.
Sun's Declination	23	17	N.
Diff. is Lat. in	32	55	S.

Variety 2. The Sun between the Equinoctial and the Zenith.

Example.

Example.

Suppoſe the Sun's Zenith Diſt. to be 35°. South, and the Sun's Declination 10°. N. The Rule is; the Sum of the Zenith Diſt. and Declination is the Lat. of the Place of the ſame Name with the Declination; for Z ⊙ + ⊙ E = Z E = O N. the Latitude North.

Arithmetical.

To the Sun's Zen. Diſt Z ⊙	35 S.
Add the Sun's Declin. E ⊙	10 N.
Sum is the Latitude required = Z E	45 N.

Example 2. in South Latitude.

	°	′	
Sun's Zenith Diſt.	20	14	N.
Declination	19	52	S.
Latitude in	40	06	S.

Variety 3. The Sun between the Zenith and the elevated Pole, and then the Rule is; ſubtract the Zenith Diſt. from the Declination, the Remainder is the Lat. of the ſame Name with the Declination.

Example in North Lat.

Suppoſe the Sun's Declination be E ⊙ 20 N°. and his Zenith Diſt. Z ⊙ 10°. North, What is the Lat?
Z ⊙ − E ⊙ = Z ⊙ = N. NPO, the Height of the Pole or Lat. North.

Arith-

Arithmetical.

		°
Sun's Declin.	E ⊙	20 N.
Zenith Diſt	Z ⊙	10 N.
Diff. is the Latitude required —	N P O,	10 N.

Example 2. In South Latitude.

	°	′	
Sun's Declination	22	30	S.
Zenith Diſtance	12	15	S.
Latitude of the Place	10	15	S.

Variety 4. The Sun between the elevated Pole and the Horizon (that is when the Sun or Star comes to the Meridian below the Pole) the Rule is; ſubtract the Comp. of the Sun's Declination from the Zenith Diſt. the Remainder is the Comp. of the Latitude.

Or thus,

Add the Zenith Diſt. to the Declination, and ſubtract that Sum from 180°; the Remainder is the Latitude, of the ſame Name with the Declination.

Admit in a Ship at Sea on the Coaſt of *Greenland*, I obſerve the Sun's meridional Zenith Diſt. (at Midnight) to be 79°. 50′. North, the Sun's Declination being 20°: 40′. North, I demand the Latitude the Ship is in?

N P ⊙ — Z ⊙ = ⊙ Z N P Comp. Lat.

Arith-

Arithmetical.

From —— Co. Declin. —— N° P ⊙	69° : 20′	
Subtract Zenith Dist. —— Z ⊙	79 : 50	
Remains Co. Lat. ——	10 : 30	
Subtract from —	90 : 00	
Lat. of the Ship	79 : 30	N°.

Or thus;

To the Zen. Dist. Z ⊙	79° : 50′	
Add the Declin. —— Q ⊙	20 : 40	
—— Sum =	100 : 30	
—— Subtract from	180 : 00	
Remains the Lat.	79 : 30	N.

Examp. 2. Of Stars near the North or South Poles, that never rise nor set in high Latitudes, (and come to the Meridian twice in 24 Hours.)

A Star's Zenith Dist. is —— 42° : 14′ N°.
And his Declin. —— —— 87° : 46′ N°.
I demand the Lat. of the Place?

*Zenith Dist.	42° : 14′	N°.
*Declin.	87 : 46	N°.
Sum	130 : 00	
Subtract from	180 : 00	
Lat. of the Place	50 : 00	N°.

Variety 5. If the Sun or Stars have no Declination (that is, if they are on the Equinoctial) the Zenith Dist. is the Lat. contrary to its Name.

Examp.

Example.

A Ship at Sea *March* 10th, or *Sept.* 12th, observes the Sun on the Meridian to the Southward of the Zenith 50° what is her Lat?

From the Zen. Dist. 50 : S.
Subtract the Declin. 00

Ex. Zenith Dist. 50° : N.
The Lat is —— 50 : S.

Variety 5th. If the Sun or Star be in the Zenith, (that is directly over your Head) the Declination is the Lat. and of the same Name with the Declination.

Example.

A Ship at Sea *June* 30th, between the Tropicks, observes the Sun in the Zenith.

The Sun's Declination being then 22° : 12′ N.
The Latitude the Ship is in, is also 22° : 12′ N.
As is plain from the annex'd Scheme.

Exam. 2. The Sun in the Zenith, and his Declin. 15° : 30′ S°. The Lat. is likewise 15° : 30′ S°.

Examp. 3. Suppose I were at Sea and observe the Sun's Zenith Dist. 20° : 57′ N°. and the Declin. be also 20° : 57′ North.

From Zenith Dist. —— —— 20° : 57′ N°.
Take the Declin. —— —— 20 : 57 N°.

Remain's Lat. —— —— 00 : 00 N°.

So that the Ship is under the Equinoctial.

I have omitted the Projections of the foregoing Schemes since they are so very easy to protract; for having with a Chord of 60 describ'd a Circle, and croſt it at Right-angles with Zenith, Nadir and Horizon.

2. Set off the Sun's Zenith Diſt from Z, towards H, if it be Southward, or from Z toward O, if Northward.

3. If the Sun or Star hath Norh Declin. the Equinoctial muſt be ſet off to the Southward of the Sun: And if the Sun hath South Declination, it muſt be placed to the Northward of the Sun.

4. The Equinoctial being thus found, draw thro' the Center of the Circle the Equinoctial E Q, and croſs it at Right-angles, with the Axis N. S. Then if you find the North Pole in your Figure above the Horizon Line H O, you are in North Latitude: If the South Pole be above it you are in South Latitude.

N. B. The foregoing Rules will ſerve to find the Lat. by any of the known fixed Stars, if you work with the Comp. of any known Star's Altitude, or it's Zenith Diſt. obſerv'd with a Foreſtaff when that Star is on the Meridian. To find which we come now to ſhew by our Tables.

Having look'd the Right Aſcenſion of both the Star and Sun in their proper Tables, ſubtract the Right Aſcenſion of the Sun from the Right Aſcenſion of the Star: But if the Star's Right Aſcenſion be leſs than the Sun's, (ſo that you cannot ſubtract, becauſe the Sun and the Star are on contrary Sides of the firſt Point of *Aries*.) Add thereto 24 Hours, and then ſubtract, and the Remainder, if under 12 Hours, is the Time of that Star's coming on the Meridian Afternoon; but if the Remainder be more than 12 Hours, ſubtract 12 Hours from it, and the Remainder is the Time after Midnight.

Or

Or thus;

To the Comp. of the Sun's Right Aſcenſion, add the Right Aſcenſion of the Star; the Sum is the Time of that Star's Southing. If the Sum exceed 12 or 24 Hours, take 12 or 24 Hours from it, and the Remainder is the Star's Southing.

Example.

On *December* 1, 1724, I demand at what Time the *Bull*'s South Eye *Aldebaran* comes to (the South) or on the Meridian?

	h.	m:	
Right Aſcenſion *Bull*'s Eye	4	17	
Add	24	00	
Sum.	28	17	
Sun's Right Aſcenſion ——	17	15	Sub.
Bull's Eye South at Night	11	02	

Or thus;

	h.	m.
To the Comp. ⊙ Right Aſcen.	6	45
Add the Right Aſcen. of the *	4	17
It gives as before —— —	11	02

Examp. 2.

To find at any time what Star is then upon the Meridian.

To the Sun's Right Aſcenſion add the Time from Noon given, and the Sum is the Right Aſcenſion of that Point of Heaven, that will come to the Meridian at the propoſed Time; with which enter the Table of the Star's Right Aſcenſion, and ſee what Star hath ſuch Right Aſcenſion, or neareſt thereto, and that is the Star ſought for.

Example.

November 6th, 1724, let it be requir'd to know what Star will be upon the Meridian at 12 a Clock at Night?

	h.	m.
Sun's Right Aſcenſion ——	15	: 27
The Time from Noon ——	12	: 00
Sum	27	: 27
Reject.	24	: 00
Star's Right Aſcenſion =	3	: 27

The Star that is neareſt in Right Aſcenſion, is the brighteſt of the Seven Stars or *Pleiades*, whoſe Right Aſcenſion is $3^{h.} : 28'.$

§. VIII. *Southing of remarkable Stars at Midnight throughout the Year.*

In *January*, none remarkable at Midnight, but the *Bull's Eye* comes to the Meridian *Jan.* 1, at $8^{h.}\ 42^{m.}$ Evening.

	day.		h. m.	
Jan.	5	*Taurus* ♉ or * *Bull's Eye*, South at —— ——	8-26	in the Even.
	10		8-04	
	15		7-43	
	20		7-23	
	25		7-02	
	30		6-42	

			h. m.	
Feb.	1	*Bull's Eye* South at	6--35	Evening.
	5		6--19	
	10		6--00	
	15		5--41	
	20		5--22	
	25		5--04	

Feb.

Feb.
- 3 * *Lion's Heart.*
- 6 * *Lion's Neck.*
- 16 Lower of the two foremoſt.

} S°. at Midnight.

* in □ of the great *Bear.*

Day.

Mar. S°. at Midnight.
- 2 * *Lion's Tail.* ——
- 3 * Lower of the two,
- 12 * Later in □ of the great *Bear*
- 21 * Upper of two later in □ of the
- 28 great *Bear,* ——
- 29 * Laſt but two in gr^t. *Bear*'s Tail,
- * *Virgin's Spike,* ——
- * Laſt but one in gr^t. *Bear*'s Tail.

Apr. S°. at Midnight.
- 4 * Laſt in great *Bear*'s Tail,
- 11 * *Dragon*'s Tail ——
- 12 * *Arcturus* in *Bootes*'s Skirt,
- 20 * South Scale of ♎.
- 26 * Upper of two foremoſt in
- 30 □ of little *Bear,* —— ——
- * North Scale of ♎.

May. South a Midnight.
- 3 * Brighteſt in the Crown.
- 5 * Brighteſt in *Serpent*'s Neck.
- 9 * *Scorpion*'s Forehead.
- 14 * *Scorpion*'s Heart.

June 17th, * Brighteſt in the *Harp* on the Meridian at Midnight.

July. S° at Midnight.
- 5 * Brighteſt between the *Eagle*'s Shoulder.
- 18 * In the *Swan*'s Tail.

Aug. S°. at Midn.
- 21 * *Fomelhaut.*
- 25 * Firſt, In *Pegaſus*'s Wing.

Sept.	11	* *Andromeda*'s Head.	S°. at Midnight
	23	* End of *Pegasus*'s Wing.	
		Pole *.	
	25	S°. in *Andromeda*'s Girdle.	

			h. m.	
Sept.	1	——	4—58	in the Morn.
	5		4—48	
	10	* *Bull*'s S°. Eye on the	4—26	
	16	Meridian, at	4—04	
	22		3—42	
	28	——	3—20	

Octob. 11.—*Andromeda*'s southermost Foot on the Meridian at Midnight.

			h. m.	
Octo.	1	——	3—9	In the Morning.
	5		2—55	
	10	S°. Eye of the *Bull* on	2—36	
	15	the Meridian at	2—17	
	20		1—57	
	25	——	1—38	
	30		1—18	

Nov.	16	*S°. Eye of the *Bull*.	S°. at Midnight.
	25	* *Capella*, or the *Goat*.	
	27	* *Orion*'s left Foot.	
	29	* In the *Bull*'s Horn.	

			h. m.	
Nov.	2		1—06	Even. Morn.
	7		0—46	
	12	*Bull*'s South Eye on the	0—24	
	17	the Meridian at	0—02	
	22		11—41	
	29		11—11	

Decemb.

Dec.	1	* First in *Orion*'s Belt.	South at Midnight.
	3	* Last in *Orion*'s Belt.	
	5	* *Orion*'s Right Shoulder.	
	7	* *Auriga*'s Right Shoulder	
	13	* Foot of the great Dog, or *Syrius*.	
	15	* Bright Foot of ♊.	
	18	* Mouth of the great Dog.	
	29	* *Castor* in ♊	
	30	* *Pollux* in ♊	

			h. m.	
	2		10--57	In the Evening.
	4		10--48	
	6		10--39	
	8		10--30	
	12		10--12	
Dec.	16	South Eye of the *Bull* on the Meridian, at	9--53	
	19		9--40	
	21		9--32	
	24		9--19	
	28		9--01	
	31		8--47	

To find when any Star that you know comes on the Meridian, do thus;

Take his Altitude by the Fore-staff, then subtract his Altitude from his Declination; but if the Altitude exceed the Decl. add thereto 24 Hours, or 3 : 60. and then subtract; the Remainder reduc'd into Time gives the Hour and Minute when that Star culminates, or comes to the Meridian. This is so plain it needs no *Example*.

To find the Latitude by the Stars.

To find the Height of the Pole or Lat. by the highest and lowest Meridian Altitude of the Stars (that doth not set) as in our Table, the great *Bear*, northern *Crown*, &c. the Declination of the Star being also given.

Rule.

Rule. If you obſerve the higheſt Meridian Alt. of a Star when he is above the Pole; ſubtract the Comp. of that Star's Declination from its higheſt Meridian Altitude, and the Remainder is the Height of the Pole or Lat. you are in.

Example.

Admit that you obſerve the uppermoſt Star of the two foremoſt of the Square of the great *Bear*, and find its higheſt Meridian Altitude (by a Foreſtaff) 59°: 30'; this Star's Declination being 63°: 32' North, given to find the Lat.

Star's polar Diſt. or Comp. Decl.——	26°: 28'
From Merid. Alt of the * ſubt.	59 : 30
Height of the Pole or Lat. N°.	33 : 02

Example 2.

Admit I obſerve the aboveſaid Star under the Pole, and find its loweſt Merid. Alt. 6°: 34' and its Declination as before, 63°: 32' North, or its polar Diſt. 26°: 28', What Lat. am I in?

*'s polar Diſt. —— ——	26°: 28'
his Altitude, add —— ——	6 : 34
Lat. in —— ——	33 : 02 N°.

To find the Lat. by the Stars that do not ſet; without their Declination or polar Diſt.

Rule. If you obſerve the higheſt and loweſt Meridian Altitude of a Star that doth not ſet, and add them together, ½ that Sum will be the Lat.

Examp. Admit you have not a Table of the Star's Declination, and yet would know by the Stars; having obſerv'd as before, the higheſt Meridian

ridian Alt. of a Star; ſuppoſe the upper of the two foremoſt in the Square of the great *Bear*, and find it 59° : 30′, then 12 Hours after I obſerve the ſame Star on the Meridian below the Pole, and find its loweſt Meridian Altitude 6° : 34′, I Demand the Lat?

Greateſt Leaſt	Merid. Alt.	59° : 30′ 6 : 34	
	Sum	66 : 04	
½ Sum is the Lat.		33 : 02	North.

The ſame is to be underſtood of any other Star that doth not ſet, as well in South Lat. as North.

Note, You ſhould not alter your Parallel till both Obſervations be made, for it will cauſe ſome Error, (and ſo much the greater the further you are from the Parallel of your firſt Obſervation) when you obſerve the loweſt altitude of the Star.

To Obſerve by the North (or Pole) Star.

This Star is called the Pole-Star, becauſe it's the neareſt to the North, or Artick Pole, but is not in the ſaid Pole, but about 2° ₂ diſtant from it, and hath been at a greater Diſtance; however 'twill be nearer and nearer, till the year 2100, when it will be leſs than 30 Min. from the Pole; but then after that will move farther and farther from it; ſo that in the Year 12700, (if the World laſt ſo long) it will be 48° from the ſaid Pole, as ſome Authors have obſerved.

When the brighteſt of the Guards is	N°. ſubt.	2° : 4′	From the Pole Stars Altitude, to the Pole Stars Alt. and the Sum or Differ. is the Lat. or Height of the Pole.
	W. ſubt.	1 : 10	
	S°. Add	2 : 4	
	E′. Add	1 : 10	

And

And to know which of these Points the Guards are upon (from the North Star) imagine a Line drawn from your Zenith thro' the Pole-Star to the Horizon, and that shall be a Line of North and South, by which you shall know when the Guards are North or South; for when you perceive the brightest of the Guards exactly on that Line under the Pole-Star, (that is to say perpendicular under it) you may conclude, that the Guards are North; but when the brightest of the Guards is on the same Line perpendicularly above the Pole-Star, then are the Guards South. As for the other two Points, imagine likewise a Line of East and West drawn parallel to the Horizon, through the Pole-Star, (that is, cross, or at Right-angles, upon the Line of North and South); and when you see the brightest of the Guards on that Line with the Pole-Star, and to the Right-hand, the Guards are East; if on the Left-hand West; and then is the best time to make your Observation at the Pole-Star; *i. e.* when the Guards are either East or West.

Now to find the Lat. by the Pole-Star and Guards: Wait till the brightest of the Guards be exactly upon one of the Points of the Compass, set down in your Table (that is to say, either East, West, North or South from the Pole-Star) for that is the best time to observe the Altitude of the North Star; to which, if you add or subtract what your Table sheweth, you shall have the Height of the Pole.

Example 1.

Admit that I observe the Altitude of the North Star to be 40° : 30′ above the Horizon, the Guards being then East from it; What is the Height of the Pole or Lat?

Alt.

Alt. of the Pole-Star,	40° : 30′	
Brighteſt of the Guards bearing East, add	1 : 10	
Height of the Pole or Lat. I am in.	41 : 40	N°.

Obſerve that the Guards are Eaſt or Weſt, when you find that the brighteſt of them is neither higher nor lower than the North-Star, which you may eaſily diſcover with your Croſs-Staff or Quadrant, as ſoon as you have obſerved the Altitude of the North Star.

§. IX. *The Deſcription and Uſe of the* Nocturnal.

1. The *Nocturnal* conſiſts of three Parts; the firſt, term'd the unmoveable Part, is the broadeſt and greateſt, on which is a Handle to hold it by in time of Obſervation, or uſing of it.

On the foreſide of which, in the outtermoſt Circle, are the 12 Months, and each Month ſubdivided into its reſpective Days, or at leaſt every two Days: They are counted towards the right Hand, mark'd with their Names, or the firſt three Letters thereof; as *Jan.* for *January*, *Feb.* for *February*, *&c.*

Within the Circle of Months, as a Circle divided into 24 Hours, and each divided into halves and quarters, on the backſide of the *Nocturnal* are the 32 Points of the Mariner's Compaſs, South uppermoſt, and Eaſt on the Left-hand: To each Point is ſet the Declination of the North Star, above or under the Pole which is known by und. for under, and abo. for above.

The

The *Nocturnals* are now made for both great and little Bears, having either two Circles of Months, marked G B, and L B; or two ſhort Teeth or Indexes, proceeding from the ſecond or middle Part of it, and marked G B, and L B, ſignifying great *Bear* and little *Bear*.

The third and moveable Part is called the Index; it is uppermoſt, on the foreſide of the Inſtrument, having one Edge proceeding in a Right-line from the Center, which (in time of Obſervation) muſt be turned to the Guards: Through all 3 Pieces, in the Center of the Inſtrument, is a Hole, through which you are to ſee the North-Star when the Index is turned to the Guards.

The Uſe of the Nocturnal.

By it may be found the Hour of the Night, the Bearing of the Guards, and the Declination of the North-Star from the Pole; by which may be found the Latitude of the Place.

1. *To find the Hour of the Night.*

1. Place the Index of the ſecond or middle Piece, to the Day of the Month, where it's to be kept till the Obſervation is ended; then taking the Handle in your Hand with the foreſide towards you.

2. And holding it upright (which you may diſcern when you do ſo, by the tip on the Top of the firſt or great Part of the *Nocturnal*) look thro' the Hole in the Center for the North-Star.

3. Turn that Edge of the long Index, which proceedeth from the Center of the Guards, ſeeing at the ſame time the North-Star thro' that Hole; then will the Index ſhew the Hour of the Night, on the ſecond or middle Part.

2. To

2. To find the Bearing of the Guards either of the little or great Bear; that is, upon what Point of the Compaſs they are, and thereby the North-Star's Declination from the Pole and Lat. of the Place, having the Height of the North-Star taken with a Fore-ſtaff alſo given.

Example.

December the 20th, at *6* of the Clock in the Morning, obſerving the Pointers or Guards of the great *Bear* by the Edge of the Index; I demand their Bearing, and Declination of the North-Star?

Right againſt the Edge of the Index proceeding from the Center, and on the back-ſide of the *Nocturnal* is S. W. by S. the Point of the Compaſs required: And on the ſaid Point of the Compaſs is 2°: 33′ und. ſignifying the North-Star is then 2°: 33′ under the Pole. And at the ſame time obſerving with the Fore-ſtaff, I find the Altitude of the North-Star to be 43°: 30′; I demand the Latitude of the Place of Obſervation?

To the Alt. of the North-Star	43°: 3
Add its Declin. from the Pole under	2 : 33
Sum is the Lat. required,	46 : 03 N°.

Example 2.

February the 14th, I obſerve (with the *Nocturnal*, the Index of the little Bear L B, being ſet to the Day of the Month) at 7 a Clock in the Evening the Guards of the little *Bear*, by the Edge of the long Index; I demand their Bearing and Declination of the North-Star?

Seeing the North-Star through the Hole in the middle, and the Guards of the little *Bear*, by the Center-edge of the long Index, and the Index cutting 7 of the Clock: Then on the back-side of the Nocturnal, and againſt the ſaid Edge of the Index is N. E. the Point of their Bearing; and on the ſaid Point is figured 0°: 35′ abo. which ſignifieth the North-Star is then 35 Min above the Pole,

Admit at the ſame time I obſerve by the Foreſtaff, and find the Altitude of the North-Star to be 46: 38′; I demand the Latitude of the Place?

From the Alt. of the North-Star	46° : 38′
Sub. its Declin. above the Pole	00 : 35
Remainder is the Lat. requir'd	46 : 03

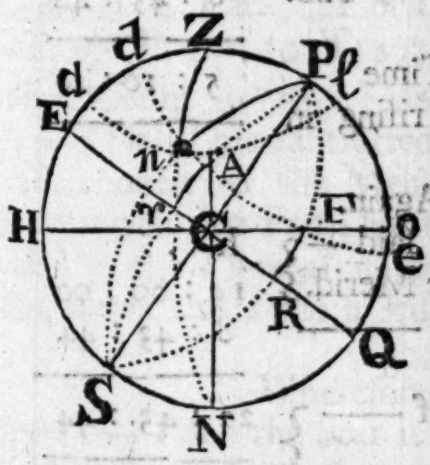
There are other Uſes of the *Nocturnal*; as to find the Moon's Southing and High-water, but I judge that is better done by the Pen, as was directed in Page 5th, of *Coaſting Navigation.*

CHAP.

CHAP. VI. Sect. I.

To find the Time of the riſing and ſetting of the Stars, their Amplitudes, Azimuths, Hour of the Night, &c.

APRIL 1. 1724, the *brighteſt Star in the Crown* comes to the Meridian 14^h. after the Sun (or Afternoon) his Declination is 27° : 51′ North; I demand its Amplitude, Riſing, and Setting, its Height, and the Time when it will be due Eaſt or Weſt, the Hour of the Night, and Azimuth, (when the Altitude taken by the Fore-ſtaff is 45°) in the Lat. of *London*, which is 51° : 32′ North?



In the adjacent Scheme Let PESQ repreſent the Meridian, PS, the Axis, EQ, the Equinoctial; ZN, the Prime Vertical; HO the Horizon, and *de* the Parallel of any Star, as the *brighteſt in the Crown*'s Courſe. If thro' the Poles P and S and F, the Interſection of the Parallel *de*, with the Horizon, A, Meridian, or Hour Circle, PFS be drawn, in the Triangle CFR, is given the Angle at C, the

the Comp. Lat. 38° : 28′, and F R, the Star's Declination 27° : 51° North, to find C F its Amplitude, and C R the Star's aſcenſional Difference, by Prob. 8. *Aſtronom. Prob.* foregoing, *viz.*

As S. C. Lat. .. ℞ : : S. *'s Decl. .. S. *'s Ampl.
— S. 38° : 30′ S. 90 — S. 27° : 51′ — S. 48° : 38′.

Which being always the ſame way with the Declination, is therefore Northerly: So that the Star riſes Eaſt 48° : 38′ Northerly.

2. For C R, the Star's Aſcenſion *x*.

As ℞ .. T. Lat. : : T. * Decl. .. S. * Aſc. *x*.
T. 45° — T. — 51° : 30′ T. 27° 51′ — S. 41° : 36′.

Which reduced into Time, is 2ʰ. 43′ : 44″; and this added to 6 Hours, becauſe the Lat. and Declination are both North, gives the ſpace of Time the Star required to paſs from the Horizon to the Meridian. The Sum taken, therefore, from the Time that it paſſes the Meridian, ſhews the Time of its riſing, but added, gives the Time of its ſetting.

	h.	′	″
April 1. 1724. The * given tranſits the Meridian at	14	00	00
x. Aſcenſion + 6ʰ. Sub.	8	43	44
Remainder is the Time of the given *'s riſing in the Evening.	5	16	16

Again.

	h.	.	
To the Time of the ſaid — Star's coming to the Merid.	14	00	00
Add the ſame Time ——	8	43	44
It gives the Time of —— the Star's ſetting.	22	43	44

	h.	′	′
From Noon; or at —— in the Morning, rejecting 12 Hours.	10	43	44

Thirdly.

Thirdly.

From the ſame *Data*, and in the foregoing Figure, to find its Height, and the Time when the ſaid Star will be due Eaſt or Weſt.

Conſtruction.

Through the Interſection of the Star's Parallel of Declination, with the Prime Vertical at A and P and S, deſcribe another Hour-Circle or Meridian, as P A ♈ S; then in the Right-angled ſpherical Triangle, C A ♈, are given the Angle at C, equal to the Lat. 51° : 30′ N. and A ♈, the Star's Declin. 27° : 51′ N°. to find A C, its Altitude, and C ♈, the Time when it will be due Eaſt or Weſt?

By Prob. 15. *Aſtronomic. Prob.*

As S. Lat. .. S. * Decl. :: R .. S * Alt. E. or W.
—S. 51° : 30′ S. 27° : 51′ —S. 90—S. 36° : 39′

Again.

As R .. T. C. Lat. :: T * Decl. .. S. of an Arch.
—T. 45° T. 38° : 30′ T. 27° : 51′ —S. 24° : 51′

Whoſe Comp. 65° : 09′, converted into Time, is 4^h. 20′ : 28′. This ſubtracted from the Time of the Star's coming to the Meridian gives the Time it will appear due Eaſt; but the ſaid Arch of Time, added to the Time of its paſſing over the Meridian, ſhews the Time it will be due Weſt.

Wherefore,

	h	′	″
From the Time the Star is on the Meridian, *April* 1.	14	: 00	: 00
Subt. the Arch laſt found	4	: 20	: 28
Time when * is due Eaſt,	9	: 39	: 32

Again.	h.	′	″
The Star on the Meridian at —	14	00	00
Add the ſaid Arch ——	4	20	28
It gives —	18	20	28
Reject	12		
	6	20	28

The Time the Star is due Weſt in the Morning.

Fourthly.

The Altitude of the Star 45°. its Declination 27° : 51′ N. and the Lat. 51 ½ N. given, as before; to find its Azimuth, and the Hour of the Night? *Conſtruction.*

In the former Scheme draw *a n l*, parallel to the Horizon, at the Diſt. of 45°, the Stars Altitude, through the Interſection of this, with the Parallel of Declination *d n e*; at *n* draw the Hour Circle P *n* S; alſo the Vertical or Azimuth Circle Z *n* N: Then in the oblique ſpherical Triangle, Z P *n*, are given Z P, the Comp. of the Lat. 38° : 30′. Z *n*, the Comp. of the Star's Alt. 45′ and P *n*, the Comp. of its Declination, 62° : 09. To find the Angle *n* Z P, the Star's Azimuth, and the Angle Z P *n*, (the Hour from Noon): Wherefore, by the 19th *Aſtron. Prob.*

Preparation.

To the Comp.	Lat. ——	38°	: 30′
Add the Comp.	Alt. ——	45	: 00
	Decl. ——	62	: 09
	Sum	145	: 39
From half the Sum —— ——		72	: 49
Take the Comp. Declin. ——		62	: 09
The Remainder call the Diff.		10	: 40

Then,

Then,

As R .. S. C. Lat. :: S. C. Alt. .. 4th Sine.
— S. 90— S. 38° : 30′ — S. 45° — 26° : 07′
As 4th S. .. S. ½ Z Sides :: S. *x*. .. 7th Sine.
S. 26° : 07′ — S. 72 : 49′ — S. 10° : 40′ S. 23° : 41′.
Whose Logarithm is —— —— 9.603913

Radius added is —— 19.603913

½ = S. C. 50° : 40 —— —— 9.801956
Doubled 50 : 40

Sum 101 : 2° the Star's Azimuth from the North at that Altitude.

For the Hour of the Night, 'twill be,

As S. C. Decl. .. S. Azim :: S. C. Alt. .. S. Arch.
— S. 62° : 09′ S. 101° : 20′ S. 45° — S. 52° : 57′ =

the Angle Z P *n*; which converted into Time, is 3ʰ. : 33′. This ſubtracted from the Star's Southing 14ʰ. (before found) gives the Hour of the Night (10ʰ. : 27) if the Star were on the Eaſt-ſide of the Meridian; but added to the time of the Southing, gives 17ʰ : 33′ (or 5ʰ 33′ after Midnight) the Hour of the Night, when the ſaid Star is on the Weſt-ſide of, or is paſt the Meridian.

Laſtly, and generally, whatever has been done in relation to the Sun, will hold good in the fixed Stars; provided that in the room of the Sun's coming to the Meridian (which is every Day at Noon) be uſed that of the Star's Culminating, or Southing, which we have already ſhewn how to find.

§. 2. The Practical Queſtions in Aſtronomy ſolved by Inſpection, by our Tables in a general Example, *viz.*

Sept. 14th, 1723. In the Lat. of 43 North, I demand the Sun's Declination, Amplitude, Riſing and Setting; Length of the Day and Night; the the Sun's Right Aſcenſion, *&c.*

1. In Table of the Sun's Decl. look the Month *September* at Top, and the day of the Month in the Side Column, and in the common Angle of Meeting you have the Sun's Declination 0°: 39′ South.

2. After the ſame manner, in the Table ☉ R^t. Aſcenſion, you'll find the Sun's Right Aſcenſion *Sept.* the 14th, to be $12^{h.}: 6^{m.}$.

3. To find the Sun's Amplitude, which is the Diſt. of Riſing or Setting of the Sun or Star, from the Eaſt or Weſt Points of the Horizon.

Examp. 1. Let it be requir'd to find the Sun's Amplitude on the 20th of *October*, 1723, in the Lat. 43 N°, the Sun's Declination for that Time is 14°: S°. Therefore look for the Declin. 14° at the Head of the Table of ☉'s Amplitude, and the Lat. 43° in the firſt Column on the Left-hand, and in the common Angle of Meeting is the Sun's Amplitude 19°: 19′ S. that is, the Sun riſes E. 19° 19′ S. and ſets W. 19°: 19′ S. for the Sun's Amplitude is always of the ſame Name with his Declination.

Examp. 2. The Lat. 43° N°. and Sun's Decl. Suppoſe 20°: 25 North, what is his Amplitude? Becauſe the Lat. and Declination are not even Deg. in the Table, we muſt take the proportional Part for the odd Minutes of the Sun's Declin. thus;

Sun's Amp. in Lat. 43°.	for	20°.	Decl. is	27° : 53′
		21		29 : 27
				m.
Subt. and their Diff. is =				1 : 24 = 84

Then

Then ſay by Proportion;

As $1° = 60^m$. .. 84′ :: 25′ .. 35′ prop. Part.

Then

Lat. 43°. Declin. 20° ⊙ Amp. is 27° : 53′
To it add the prop. Part above 0 : 35

Gives Ampl. for Decl. 20° : 25′ = 28 : 28 N.

That is, the ⊙ { riſes } E. 28° : 28′ North.
{ ſets } W. 28 : 28 North.

Example 3.

Let the Lat. be 43° : 30′ N. and Declination as in the laſt Example, 20° : 25′ N. What is the Sun's Amp?

For Lat. 43°. and Decl. 20° : 00′ } Amp.
the Amp. is —— —— —— } 27° : 58′
For Lat. 43° and Decl 21° : 00′ 29 : 17

Diff. as before = 1 : 24

As 60′ .. 84′ :: 25′ .. 35′ prop. Part.
And 27° : 58′ + 35′ = 28° : 28′ the Sun's Amp. for 20° : 25′ North Declin. in Lat. 43° North.

Again.

		Amp.
For Lat. 44° and Decl.	20	28° : 23′
	21	29 : 46
Their Diff. is =		1 : 23

As 60′ : 83′ :: 25′ .. 34′ prop. Part.
And 28° : 23′ + 34 = 28° 57′ the Sun's Amp. in Lat. 44°, with 20 Deg. 25′ Declination.

Now, becauſe the given Lat. 43° : 30′ is in the middle, between 43° and 44°, therefore the Medium of the Amplitudes before found is the Amplitude requir'd. Thus:

Lat. $\left\{\begin{matrix}43^\circ\\44\end{matrix}\right\}$ Decl. 20° : 25′. the Ampl. is $\left\{\begin{matrix}28^\circ : 28'\\28 : 57\end{matrix}\right.$

Sum = 57 : 25

½ the Sum is the Ampl. requir'd, 28 : 42 N.

Thus may the Amplitude be found for any odd Minutes of Lat. or Declination, tho' the Table is calculated for whole Degrees only.

Example 4.

In the Lat. of 43°, the Sun's Declin. being 23 ½ North, I demand the Time of the Sun's Rising and Setting, with the Length of the Day and Night?

Find the Lat. 43° at the Head of the Table (of the Sun's Rising and Setting) and the Degrees of the Sun's Declin. in the Left-hand Column, and in the common Angle of Meeeting you have the Sun setting $7^h. : 36^m.$ becauſe the Declination is North.

Sun-ſetting	7h. : 36′
Subtract from	12 : 00
Sun-riſing is	4 : 24

	h.	m.
Sun-ſetting doubled is the Length of the Day	15	12

	h.	m.
Sun-riſing doubled is the Length of the Night	8	48

If there be odd Minutes of the Lat. or Declination, or both, you may find the proportional Part after the ſame manner as was exhibited in Example 2d and 3d of the Sun's Amplitude foregoing.

5. To

5. To find the Time of any Star's Rising and Setting, whose Declination exceeds not the Sun's, *Viz.* 23° : 30′ by the aboveſaid Table.

Example 1.

Decemb. 4th, 1723, I demand the Time of the Riſing and Setting of the *Bull*'s South Eye, or *Aldebaran*, whoſe Declination is 15° : 48′ North, in the Lat. of 48° North?

Look in the left Side of the Table 16° (neareſt to 15° : 48′) of Declination, and the Lat. 48° in the Head thereof, and in the common Angle of Meeting you have the Star's ſemi-diurnal Arch, (or ½ the Time that Star doth continue above the Horizon in that Lat. or the Diſt. of Time that Star is in going from the Horizon to the Meridian on the Eaſt-ſide: Likewiſe from the Meridian to the Horizon on the Weſt-ſide of the Meridian. In this Caſe $7^h.:02^m.$ Now, if you ſubtract theſe Hours and Minutes from the Time of the Star's coming to the Meridian, (which will be found by the former Rules to be at) $10^h.$ 48′, the Remainder will be the Time of the Star's Riſing; and if you add, the Sum will be the Time of the Star's Setting.

Operation.	h.	′
The Time of the Star's Southing,	10	: 48
Its ſemi-diurnal Arch, ſubtract	7	; 02
Time of the Star's Riſing in the Even.	3	: 46
Added is	17	: 50
Reject	12	: 00
Time of the Star's Setting in the Morn.	5	: 50

Note 1. If the Sum of the Addition exceed 12 Hours, caſt away the 12 Hours.

2. And when you can't ſubtract, add 12 Hours to the Star's Southing, and then ſubtract; what remains is its Setting.

3. If you are in North Lat. and the Star hath South Declination, the Table gives the Star's ſemi-nocturnal Arch; which ſubtract from 12 Hours; the Remainder is the Star's ſemi-diurnal Arch, as before.

4. If you are in South Lat. and the Star hath North Declination, do the ſame as when you are in North Lat. and the Star hath South Declination.

Practical NAVIGATION.

PART III.

HAVING now gone thro' what I judge ſufficient in the Theory of *Navigation*, I ſhall proceed to *Practical Navigation*; or the Application of the whole, in keeping of a Reckoning, or Sea Journal; the careful Performance of which is not only the Mariner's Reputation, but (under God) the Conſervation of Ship and all in it; the Ignorance whereof hath, no doubt, been the chief Cauſe of loſing divers rich Ships, and many uſeful Subjects (of this Kingdom) and conſequently thence the impoveriſhing of ſeveral Families.

Therefore they, who take on them ſo great a Charge as the navigating Ships to remote Places, ſhould make it their great Concern to be expert herein, when ſo great a Truſt as Men's Lives and Eſtates are repoſed in them; and not to think that the learning a few Problems only in the Theory (from ſuch Teachers, who have learned to ſail on the

the Shoar on a Slate or Paper only) will make a Man a compleat Artiſt; for Navigation is no trifling Knowledge, but a Science of the utmoſt Importance; becauſe the Good both of the Publick and Private is in Danger from a very ſmall Miſtake committed therein, and therefore it ſhould be learned to the utmoſt Perfection; and ſuch Perſons who are about to learn this Art, I adviſe they would apply themſelves to a proper Maſter, *viz.* One who has Experience in the Practice, as well as a Knowledge in the Theory only, by which means they may add to the Number of the skilfulleſt Mariners that the World affords, which are my Native Countrymen of *England.*

CHAP. I.

Of a Sea Journal.

BUT to proceed in the Practice of keeping a *Sea Journal*, there are five neceſſary Things to be known by our young Navigator, *viz.* 1. That he rightly underſtands the Compaſs, with the Variation thereof; and that he muſt carefully obſerve the Courſe ſteer'd; in order to which, you are often to look to your Compaſs, and to the Wake of your Ship (if ſhe be upon a Wind) to ſet it by your Compaſs, that you may give due allowance for her Lee-ward Way.

2. The Log-line and Half-minute Glaſs; that the Knots on the Log-line be a due Length, and your Glaſs juſt half a Minute.

Now as the ½ Minute Glaſs is $\frac{1}{120}$ part of an Hour, ſo the Log-line Diviſions or Knots ought

to be the $\frac{1}{120}$ part of a Sea Mile. A Statute Mile contains 5280 Engliſh Feet; and 5280 divided by 120 Quotes 44 Feet; but we uſually allow but 42 Feet, or 7 Fathom between Knot and Knot on the Log-line, altho ſeveral Authors of Navigation have contended for 50 Feet Diſtance between the Knots, depending upon ſuch Land Experiments as have been made, that 66, or 70 Miles makes one Degree of a great Circle upon the Superficies of the Earth or Sea; but I ſhall rather adhere to the good old Way of 42 Feet, for theſe Reaſons, *viz.* 1. To give allowance for the Way that the Log makes after the Ship; for altho' there is 12, 15, or 18 Fathom of ſtray Line, (ſo much) allow'd as may be ſuppoſed to veer the Log moderately well out of the Ship's Wake, yet it cannot be ſuppoſed but that ſtill the Log muſt have ſome Way after the Ship, if but by the Weight of the Line, which altho' but light, yet the Water being but a ſoft fluid Subſtance, the Log muſt needs have ſome Motion after the Ship, and eſpecially ſailing before the Wind; or large and in a freſh Gale, the Wind and Sea will have ſo much Effect upon the Log, and ſo much upon the ſuperficial Part of the Water, as to ſhove it along after the Ship.

2. If there be an Error in the ſhortneſs of the Knots, it is on the ſafer Side; for altho' the exact Truth is beſt, if it could be attain'd; yet if an Error muſt be, 'tis better that the Reckoning be a-head of the Ship, than that the Ship ſhould be a-head of the Reckoning; and better to look out for Land before we come at it, than to be a-ſhoar before we expect it.

3. Moſt Mariners, both in the Royal Navy, and Merchant Ships, uſe this Diviſion of the Log, and by their conſtant Practice and Experience, find the Succeſs to anſwer their Expectations in

any

any Voyage, much nearer than a much larger Diviſion would do.

Of the Half-minute Glaſs.

That the ½ Minute Glaſs be of a due Length, or otherwiſe it muſt needs make the Ship to run more or leſs than indeed ſhe does; therefore We ſhall ſhew a Way to meaſure a ½ Minute, or any ſmall Portion of Time, by the Vibrations of a Pendulum, which may be demonſtrated to be Equitemporal: This Experiment is mentioned by Mr. *Henry Philips*, in his *Advancement of the Art of Navigation*; and ſince quoted by moſt Authors of Navigation; and Experience confirms this Truth, That if there be a Pendulum whoſe Length (from the Center) is 38 ½ Inches, it vibrates Seconds, or Sixty times in a Minute; therefore for the trial of your ½ Minute Glaſſes do thus;

Take a Bullet and make faſt a Thread or Silk, of the juſt length of 38 ½ Inches; let there be a Nooſe on the end of the Thread, and let the very End of the Nooſe be juſt 38 ½ Inches from the Center of the Bullet (as aforeſaid); then hang it up by the Nooſe upon a ſmall Pin where it may hang at Liberty, and ſwing freely, and ſo give it Way, and each Swing ſhall be a true Second of Time; that is, each Time that it paſſes by the Perpendicular let fall from the Pin on which it hangs, ſhall be ½ a Second; and every time of its return to the Place where it firſt began its Motion is a true Second of Time, and a Glaſs that runs, till the ſaid Bullet hath made 30 returns, ſhall be a true half minute Glaſs.

But if the Ship hath any conſiderable Motion, make the String 7 Inches ſhorter, and there make a Knot to hold it by between your Finger and Thumb, then by the motion of the Hand cauſe the Bullet to aſcend to an Angle of about 60° every Swing from the foreſaid Perpendicular; then each

each Swing ſhall be equal to thoſe above-mentioned. But thoſe that have a Log-Line truly divided, and the Experience of a Glaſs in long Voyages of ſo true a Length, that their Dead-reckoning, (when carefully kept) hath agreed with their Obſervations, their making of Land, *&c.* hath fallen out according to Expectation, by their Account by dead-reckoning; ſuch a Glaſs, or another of the ſame Length, ought to be preferr'd before any other, as a true ½ Minute Glaſs.

3. In finding the Lat. by Obſervation, you are the firſt Opportunity, from ſome known Head Land, to obſerve, and if you find (after you have computed how far the ſaid head Land, *&c.* is to the Northward or Southward of you, and knowing its Latitude by good Tables) any apparent Fault in your Quadrant to allow for it. *i. e.* So much in your future Obſervations, as you find by this Trial your Inſtrument is Northerly, or Southerly: For altho' a Quadrant or Foreſtaff may be made by a good Workman, yet you ſhall rarely find where there are many Quadrants, or many Obſervers aboard of one and the ſame Ship, and obſerving at one and the ſame Time, that all their Obſervations ſhall be exactly the ſame, but differ ſometimes 6. 8. 10. 20. or 30 Minutes, more or leſs; which muſt be imputed to ſome Defects, in thoſe Inſtruments, or to the Difference in the obſerving, ſome Men obſerving too open, and others very cloſe, which later Sort I judge, do make the moſt accurate Obſervation, by reaſon they can eaſier, and oftner perceive the Sun's Motion when he is near the Meridian, than the former.

4. In ſailing along Shoar it's convenient and ſafe, for avoiding the Dangers of the Shoar (eſpecially on an unknown Coaſt; that is, where you are not well acquainted with the Shoals,

&c.) that you ſteer ½ a Point, or a Point, more to the Sea-ward in the Night time; alſo its neceſſary, when you come near a Port, that you have a right Underſtanding of the Quality of the Tides, which way the Floods and Ebbs ſet, and what Moon makes full Sea upon the Coaſt, that ſo it may be known how long to ride at Anchor, or lie by to wait the Tide, if you know you are too ſoon; or what Sail to make to ſave your Tide, if you fear being too late; and that by knowing the ſetting of the Flood or Ebb, you may know what Tack will be beſt to get on board, to take all the Advantages to haul your ſelf cloſe upon a Wind, (if it ſhrinks) and to judge well of your Courſe.

5. Theſe few Things being premiſed, and that our young Navigator be perfect in the Solution of the Queſtions, in plain ſailing Traverſe, Mercator's Sailing, and to allow for known Currents, or Tides, to find the Variation of the Compaſs, to take and work a celeſtial Obſervation, *&c.* all which we have fully treated of in the foregoing Pages; let us now ſuppoſe he is on board, as Maſter, Mate, Midſhipman, *&c.* taking his Charge, (or otherwiſe for his Improvement or Satisfaction,) for any Voyage: He is firſt to ſee he has good Meridian (or common) Compaſſes, and (in far Southern Voyages) an Azimuth-Compaſs together with Logs and Log-Lines, (a Reel) and Glaſſes, for a Watch (or 4 Hours) ½ Hour and ½ Minute with hand and Deep-Sea, Leads, and Lines in readineſs; alſo Journal, and Log-Books. After the Navy, or Merchant-Ships Form (ruled and titled, in the Manner we ſhall ſhew a little farther on) with a good Quadrant, (Foreſtaff and Nocturnal) for celeſtial Obſervation, plain and Gunter's-Scale, pair of Compaſſes, Sea-Charts, *&c.* for Operation; theſe Things, I

ſay,

say, being in Readineſs, he muſt alſo provide a Log-Board ruled, and mark'd as you ſee in the Figure here under.

The Form of the Log-Board.

H.	K.	F.	Courſe	Winds	Remarks
1	- -	- -		N N W.	8 *March*
2	- -	- -	Freſh	Gales and	5th. 1723.
3	- -	- -	fair	Weather	yeſterday at
4	- -	- -			6 in the E-
5	- -	- -	Reef'd	Top-Sailes	vening, we
6	- -	- -	Lizard		took our
7	4		Point bore		Departure
8	5		N W diſt.	5l. N b W.	from the
9	3	2	W S W.		*Lizard*
10	3	1			bound for
11	3	5	moderate	and fair.	*M.* in Com-
12	4	4			pany of
		6			three more
1	5	2		N W b N.	Merchant-
2	4			Wind	Ships; at 8
3	4	6	Squails of	Rain.	A. M. ſtow-
4	4	3	with		ed our An-
5	4	1			chors, and
6	3	5		N N W.	hoiſted in
7	4	3			our Long-
8	3	4			Boat.
9	3	5			
10	4	2	S W b W.		
11	5	3			
12	5	2	Moderate	and fair.	

The

The Log-Board you ſee is divided into ſix Columns, marked or noted at the Head of each Column, with Letters thus;

H, K, F, C, W } which ſtand-eth for { Hours, of the Day. / Knots, Fathoms, } run that Day. / Courſes, ſteer'd that Day. / Winds, which have blown that Day; the laſt Column is Remarks or Occurrences happening that Day, as parting with the Land, meeting or parting, with Ships Currents, ſetting of the Sea, handing of Sails, *&c.* as will plainly appear by the ſaid Log-Board, being filled up with the firſt Day's Occurrences from the Land departed from; which before you loſe ſight of, you are to ſet with the Compaſs, (allowing the Variation) and compute its Diſtance from you; then having ſettled your Watches, and order'd the Men (or Man) a Trick at the Helm for two Hours, as is uſual; let 'em obſerve carefully what Courſe he Steers by the Compaſs, or if they be order'd to ſteer upon any given Courſe, let them take care to mind it, and at the End of two Hours, or rather, and much better every Hour, (for the oftner the better) which is the Cuſtom in the royal Navy, and *Eaſt-India*-Men; let the Mate heave the Log, calling aft, a Couple of Hands (Men) to attend him, one to hold the Log-Reel, the other with the ½ Minute-Glaſs in his Hand: Let the Mate over-haul off the Line, (having firſt caſt over board, from the Taffrel, or Lee-Quarter of the Ship, the Log with three or four Fakes of Line into the Sea) till the red Rag come to his Hand, at that Inſtant the Mate ſays turn; the Man with the Glaſs immediately upon that Word, as the red Rag goes away is to turn the Glaſs, replying done; and watching diligently, when the ½ Minute

nute Glaſs is juſt out, the Man that holds the Glaſs, cries ſtop; whereupon the Mate ſtops, and hauls in the Line, obſerving exactly how many Knots and Fathoms are gone out, and ſets it down on the Log-board, againſt the Hour at which the Log was heav'd, and thus proceed every Hour, all the 24 Hours, and then the Log-board will be full, next Day at Noon.

Then having provided a Log-Book, ruled every Page like the Log-board, with the Day of the Week and Month at top, take off the Log into your Book, and rub out the Chalks upon the Log-Board, after you have ſo done (at Noon) ſo is the Board ready for the next Day.

Note, that Mariners do keep their Reckonings by the beginning and ending of the Day, aſtronomical, from Noon to Noon; that is, any 24 Hours Log, from Noon to Noon, is dated by the Day upon which it ends, and not upon the Day upon which it begins; thus if we ſet Sail *March* the 4th, that 24 Hours Log muſt be called *March* the 5th.

2. That ſome in their Log-Books, or Journals, do repreſent the Week-Days by the Characters of the 7 Planets, *viz.*

☉	Sun	For	Sunday
☽	Moon		Monday
♂	Mars		Tueſday
☿	Mercury		Wedneſday
♃	Jupiter		Thurſday
♀	Venus		Friday
♄	Saturn		Saturday

T CHAP.

CHAP. II.

Practical Navigation.

PROCEED we now to work a Days Log. And firſt, when the Ship hath had a fair Wind; that is before it, quartering, or large; we muſt make allowance always for the Variation of the Compaſs, Growth of Sea, and known Currents, lying by, making and ſhortning Sail; let the Example be taken from the foregoing Log-Board, or Log-Book, where the Ship departs from the *Lizard* Point, in the Lat. of 49°: 56′ N. and Long. 5°: 23′ W. bound, for M. in the Lat. of — and Long. of — Courſe — Diſt. — Merid. Diſt. or Depar. — found by Caſe 1. of Mercator's Sailing.

Explication or Operation.

1. At 6 laſt Night the *Lizard* did bear from the Ship, N. N. W, but allowing 1 Point Weſt Variation, (in the Chops of our *Britiſh* Channel) to the left hand, the Bearings corrected will be N. W. *b.* N. conſequently the Ships Courſe from the *Lizard* muſt be on the oppoſite Point of the Compaſs, which is S. E. *b.* S, and the Diſt. *per* Eſtimation is 5 Leagues, or 15 Miles; which is the firſt Courſe and Diſt. (in this our firſt Days Work.)

2. Ob-

2. Obſerve to allow the Variation, if Weſterly, to the left Hand of your Courſes ſteer'd, by the Compaſs, but Eaſt Variation to the Right.

To make this very plain to our young Navigator, (as alſo to allow for the Lee-Way, when the Ship is upon the Wind,) I have here ſubjoin'd a Compaſs-Card, in which he is to lay the Point of the Compaſs ſteered directly before him, and count to the right Hand or left ſo many Points, as is to be allow'd for the ſaid Variation, (or Lee-Way) and he will eaſily perceive the Courſe corrected.

3. The firſt Courſe the Ship ſteer'd was W. S. W, but allowing one Point Weſt Variation to the left Hand thereof, the Courſe corrected, or made good, is S. W. *b.* W. and the Diſt. by Log. 79 Miles during the Time the Ship lay on that Courſe, which was from 6 in the Evening till 10 a Clock next Morning.

4. The ſecond Courſe ſteer'd is S. W. *b.* W; but allowing, (as before) 1 Point Weſt Variation, the Courſe made good is S. W. and the Diſt. run by the Log from 10 to 12 a Clock at Noon is 15 Knots, or Miles, allowing 7 Fathom to each Knot, and every Knot counted as 1 Mile, when the Log is hove every Hour, (but if it's hove but once in two Hours, you muſt double the ſaid Diſt. run by the Log) and thus proceed, if there were more Courſes on the Log-Board.

This done, collect your ſeveral Courſes corrected and Diſtances ſailed into a Traverſe-Table, and work the ſaid Traverſe, as you were taught in Traverſe Sailing. See the Operation.

C	D.	P.	N.	S.	E.	W.	Lat. of the *Lizard* is
S. E. *b.* S.	15	3		12.5	8.3		49° : 56′ No. *x.* Lat.
S. W. *b.* W.	79	5		43.9		65.7	1 : 07. Sly.
S. W.	15	4		10.6		10.6	
x	Lat.	or So.		67.0		76.3	48 : 49 No. Lat. *per* Dd
						8.3	49° : 56′ Mer. Par.
		Depr. or Westing.				68.0	48 : 49 3468 — 3365
							Mer. *x.* Lat. 103 m.

As *x.* Lat. Depar. :: R .. Tang. Course — 67^{m} — 68^{m} — T45° — T45° : 34′.

As S. C. Depar. :: R .. Dist. run, — S .. 45° 34′ — 68^{m} — S. 90 — 95 Miles.

As *x.* Lat. — 67^{m} — 68^{m}
Depar. :: Merid. *x.* Lat. *x.* Long.
— 103^{m} 104^{m}. or 1° : 4′4 W.

Then *Lizard* Long. —— — 5° : 23′ W.
x. Long. —— —— —— 1 : 44 W. add.

Long. in *per* Account. 7 : 07 W.

Lastly, Because the direct Course from the *Lizard* is S : 45° : 34′ Wt. therefore the *Lizard* must bear (on the opposite Point) N°. 45° : 34′ Et. Dist. 95 Miles, or 32 Leagues. Thus is this first Days-Work finished, and you may place it down in the vacant Space to the right Hand of the Days Log, in the Log-Book, thus;

(∾ *or*) Tuesday March 5, 1724.

This 24 Hours the first Part, fresh Gailes and fair Weather, the middle sometimes moderate and fair, and other times squalls of Wind with Rain, but the latter Part, moderate and fair, at 6 P. M. the *Lizard*-Point bore off us N. N. W, dist. about 5 Leagues, from which I take my Dep. in Company with three Sail of Merchant-Men, &c My

My Course *per* Account is, S: °49° : 34′ W.
Distance — —— 95^{m}.
Southing —— — 67.
Westing — —— 68.
Lat. in *per* Dd. —— 48′ : 49′ N.
Merid. Dist. — — 68^{m} W.
x. Long. — — — 104 W.
Long. in — —— 7° : 0′7 W.
The *Lizard* bears from the Ship N. 45° : 34′ E. Dist. 32 Leagues

Note, That the three Proportions, in this Days-Work, may be wrought by *Gunter*'s Scale, by Case 6th, plain Sail. Meth. 1. and Case 2. Mercat. Sailing, or Case 2. middle Lat. Sailing. Or the *x.* Long. may be found by the Traverse-Table and middle Lat. as directed in Case 4th, middle Lat. Sail. and this, or any other Days-Work, may be wrought by the Pen or Inspection, in all the various Methods proposed in plain Sailing, to which I refer you.

The Log-Book, Ex. 2.

☿ (or *Wednesday.*) | *March* 6, 1723.

H.	K.	F.	C.	W.	Occurrences.
1	5	2	W*b*N	ENE	This 24 Hours, freſh Gailes
2	4	5			and fair Weather, and a
3	3	1			great Sea from the Eaſtern
4	3	4			Board.
5	3	3			Magnet. Amp. E 18°: 05′S
6	4	4			True Amp. E 29 : 12 S
7	4	2			Variation. W. 11 : 07
8	4	3			
9	5	4			⊙ Zenith Diſt. 50° : 17′S
10	5	1			⊙ Declinat. 1 : 30 S
11	5	3			
12	6	2			Lat. by Ob. No. 48 : 47
1	6	2			
2	6	1			Courſe W. Diſt. 136^{m}
3	6	3			Weſting o 136mo
4	6	1			Lat. *per* Acc. 48 : 4′9 N°
5	6	6			Merid. Diſt. 204^{m} W.
6	6	4			*x*. Long. °206^{m} W.
7	6	—			Long. in 10 : 33′ W.
8	6				Lizard N° 71° : 49′ E
9	5				Diſt. 72 Leagues.
10	5				
11	5				
12	6		128^{m}	by Lo.	

In this ſecond Day's Motion the Ship ſails but on one Courſe, *viz.* W. *b.* N, with Allowance for 1 Point Weſt Variation, the Courſe made good is Weſt. And with reſpect to the great Eaſtern Sea following the Ship (going quartering) I allow one Knot (or Mile) more in 10, for the Diſt. run by the Log, that is, the Run by the Log

Log being 128 Knots, or Miles, I allow 13 Miles more, which makes it 136 Miles.

Explication.

The Courſe being Weſt (or Eaſt) Diſt. 136^m the Lat. in *per* Account is the ſame as yeſterday, *viz.* 48° : 4′9, and the *x.* of Long. is found by Caſe 2d of Parallel Sailing, or by the 2d Caſe mid. Lat. Sailing, calling the Comp. mid. Lat. there the Comp. Lat. here, becauſe in this Caſe the Diſt. and Depr. are the ſame.

As S. C. Lat. *x.* Diſt. (or Depr.) :: R .. Long.
— S 41° : 11′ — 136^m —— S 90° — 206^m
or in Deg. and Min. 3° : 2′6 W, which added to the Long. the Ship was in yeſterday, *viz.* 07° : 0′7 W, gives 10° : 3′3 W the Long. the Ship is in; alſo the Weſting or Depr. 136^m added to yeſterday's Merd. Diſt. 68^m W. makes 20^m4 W. the Merd. Diſt. or whole Weſting or Depr. from the Lizard.

And Subt. the Lat. in —— — 48° : 49′N
From the Lizard's Lat. — —— 49° : 56N
the Remainder is the *x.* Lat. or Southing from the Lizard 67^m

Then to find the Bearings and Diſt. from the Lizard, we have given the *x.* Lat. 67^m and the Merd. Diſt. or Depr. 204^m to find the Courſe and Diſt. by Caſe 6th of plain Sailing.

As *x.* Lat. Depr. R .. Tang. Courſe.
67^m. — 204^m — T. 45° — T. 71° : 49′,
As S. C .. Depr. :: R .. Diſt.
S. 71° : 49′ — 204^m — S. 90° — 215^m. or near 72 Leagues. So that the Lizard bears.

N. 71° : 49′ E. Diſt. 72 Leagues, and your Day's Work is finiſhed; therefore enter all the foregoing Operations in your Log-Book; as you ſee here is done above.

Example 3. Variation ¼ pt. W.

4 (or *Thurſday*) *March* 7, 1723.

	H.	K.	C.	W.	Occurrences.
1	5	2	SW*b*S.	N E.	This 24 Hours cloſe
2	6	1			Weather, with ſome
3	7	—			Rain and freſh Gailes
4	2	—			of Wind and variable,
6	1	—		Rain	ſometime calm, a great
7		—	calm		Sea from the N. E.
		—			Board at 6 P. M. made
8	4	5	SSW.	N *b* E.	a Trial of the Current,
9	6	—		NE*b*N.	and found it to ſet E.
10	5	2	S W.		N. E. 1 ½ Knot an
11	9	3			Hour.
12	5	4		N N E.	
1	5	6		Rain	
2	6	—	SW*b*S.		Courſe S.° 31°: 12′W.
3	6	—		N E.	Diſt. —— 102m.
4	6	—			Southing 87 Miles
5	6	3	SW*b*W.		Weſting 53m. N.
6	7	—			Lat. *p.* Judgt. 47°: 20′
7	7	2			
8	6	5			Merd. Diſt. 257m. W.
9	7	1			*x.* Long. 79m. W.
10	8				Long. in 11°: 52 W.
11	8	3	SW ½ W.	NE *b* E.	Lizard N°. 58°: 4′5 E.
12	9	—	166m. *per*	Log.	Diſt. 100 Leagues.

The ſeveral Courſes corrected, by allowing ¼ Point Weſt Variation to the left Hand of each Courſe, will be as in the Traverſe-Table following, *viz.*

C.

C.	D.	P.	N.	S.	E.	W.
SS W ¼ W.	21	2¼		19.9		19.0
S *b* W ¼ W.	11	1¼		10.7		02.8
SW *b* S ¼ W.	2	3¼		17.7		13.1
S SW ¼ W.	18	2¼		16.3		07.7
S W ¼ W.	33	4¼		22.2		24.4
S W ¼ S.	25	3¼		18.5		16.8
ENE. ¼ N.	36	5¼	18.5		30.9	
			S.	105.3	83. 8 W.	
			N.	18.5	E. 30.9 sub	
			X. Lat. — 86.3 S.		Depr. 52.9 W.	

Also the Current, ſetting, E N E. corrected is E N E. ¾ N. or N E *b* E. ¼ E. at the Rate of 1 ½ Mile an Hour i is 36 Miles in 24 Hours, which I place in the Traverſe-Table, and work it with the reſt of the Courſes. Then;

As *x.* Lat. Depr. :: T. Courſe 31° : 12′
As S. C .. B :: Depr. .. Diſt. 102m.
Lat. yeſterday — — 48° : 47 Mer. P.
x. Lat. Sub. — 1 : 27 3362
Lat. to Day *per* Account. 47 : 20 — 3232
Merd. *x.* Lat. — — 130
Merd. Diſt. yeſterday 204m. W.
Weſting or Depr. made to Day 53. Add.
Merd. Diſt. to Day 257 W.
As *x.* Lat. Depr. :: Mer. *x.* Lat .. *x.* Long.
— 79m. or — — 1° : 1′9 W.
Long. yeſterday was — 10 : 33 W. Add.
Long. in to Day — — 11 : 52 W.

From Lat. Lizard — 49° : 5′6 N
Sub. Lat. by Account — 47 : 20 N.

Remains *x* Lat. 2 : 36 N.
60

Or in Miles, 156.

As

As *x* Lat. .. Dep. (or Merid. Dist.) :: Tang. 45° .. Tang. bearing off the *Liz.* N. 58° : 45′ E.

As S. C. .. Mer. Dist. :: R .. Dist. from the *Lizard* 300^{m}: or 100 Leagues. All which enter in your Log-Book as before;

Example 4. *Variation* ¾ *of a Point West.*

♀ (or *Friday*) *March* 8th. 1723.

H	K	F	C.	W.	*Occurrences.*
1	4	2	S.W.	N.E.	This 24 Hours mod. Gales and fair Weather at 4 P. M. ſpoke with a *Briſtol* Galley that came from *Leghorn*, and bound for *London.*
2	4	1	*by* W.		
3	4	3			
4	5	1			
5	3	1			
6	5	2			
7	4	5			
8	4	6			Had an Obſervation, and found a Help to the South-ward 25^{m}, which I impute to the South-weſtern Sea.
9	3	5	S.W.	E.N.E.	
10	3	4			
11	3	3			
12	4	1			
1	4	—		N.E.b.N.	Zenith Diſt. 46° : 29 S.
2	4	2			Declin.—— 0 : 43 S.
3	4	4		N. E.	
4	5	—			Lat. *per Obſ.* 45 : 46 N.
5	—	—	By up N.	N. W.	
6	4	3		*of* N.W.	Courſe S. 40° : 15′ W.
7	5	—	S.W.		Diſt. 104^{m}.
8	4	2	made		Southing 79^{m}.
9	4	3	Sail.		Weſting 67
10	4	4			Lat. *per* D^{d}. 46° : 01′ N.
11	4	5			Mer. Diſt. Correct. 312^{m}.
12	5	—			Long. Correct. 13° : 08 W.

Lizard bears North 51° : 21′ Eaſt, Diſt. 133 Leagues.

1. In

1. In this Day's Motion, the Courſes made good, with allowing $\frac{1}{4}$ *per* Weſt Variation: To the Left-hand of each are S. W. $\frac{1}{4}$ W. 23^{m} .. S. W. by S. $\frac{1}{4}$ W. 70^{m}; and lying by from 4 to 6 in the Evening, I allow 1 Mile for Drift to the N. W. And the third Courſe ſteer'd being the ſame as the ſecond, *viz.* S. W, you need only add both the Diſtances ſailed together, which makes 70^{m}. on the ſame Courſe, as above.

2. Theſe three Courſes and Diſtances reduced to one, by working a Traverſe (Table) gives the Ship's Courſe this 24 Hours, to be S. 40° : 15′ W. Diſt. 104^{m}. Southing, 79^{m}. Weſting, 65^{m}, 8 (or 67 very near)

		M. P.
Lat. Yeſterday	47° : 20′ ——	3232
x Lat. ſubt.	1 : 19	
Lat. *per* D^{d}	46 : 01 ——	3117

Merid. *x.* Lat. = 115^{m}.

To Merid. Diſt. Yeſterday	257^{m}. W.
Add Weſting made to Day	67^{m}.
Sum is Merid. Diſt. to Day	324 W.

As *x.* Lat. .. Dep. :: Mer. *x.* Lat. .. *x.* Long.

98 Miles, or	——	1° : 38′ W.
Long. in Yeſterday W.	——	11 : 52 Add
Long. in to Day *per* Acco^{t}.	——	13 : 30 W.

But ſeeing that I am but in the Lat. of 46° : 01′ by my Reckoning, and in 45° : 46′ by Obſervation (which I muſt prefer or truſt to more than the dead reckoning.) So that the Ship (ſailing to the Southward in North Lat.) hath out-run the Reckoning 25 Miles Southerly, which I judge is

an

an Error in my Steerage or Courſe, in regard of the Southweſt Sea, or that I have allow'd too little Variation of the Compaſs (for want of an Opportunity to obſerve it): Therefore, to find the Courſe, Merid. Diſt. and *x.* Long. Corrected;

Lat. *Lizard* 49° : 56′ —— 46° : 01′ is =235^{m}. the *x.* Lat. or Total Southing from the *Lizard*; and the total Weſting, or Merid. Diſt. is 334^{m}. by dead Reckoning. Then,

As *x.* Lat. .. Dep. :: R .. T. Courſe,
— 235^{m} —— 324^{m}. — T 45° — T. 54° : 10′.
As S. C. .. R :: Dep. .. Diſt.
— S. 54° : 10′ S. 10′ — 324^{m} — 399^{m}. by dead Reckoning; which with the *x.* Lat. by Obſervation from the Lizard, *viz.*

49° : 56′ — 45° : 46 = 250^{m}. find the Courſe, Weſting and *x.* Long. Corrected by Caſe 3, *Mercat. Sailing.* Thus,

	Merd. Parts.
Lat. 49° : 56′ ——	3468
Lat. 45 : 56 ——	3095
Merid. *x.* Lat. ——	373

As Diſt. .. *x.* Lat. :: R .. S. C. Courſe.
— 399^{m}. — 250^{m}. — S. 90 — S. 38° : 40′
Whoſe Comp. is 51° : 20. So that the *Lizard* bears N. 51° : 20′ Eaſt. Diſt. 399^{m}. Leagues.

As R .. S. C. :: Diſt. .. Merid. Diſt.
— S. 90 S. 51° : 20′ 399^{m} — 312^{m} W^{t}. Correct.
As *x.* Lat. .. Dep. :: *Mer. x.* Lat. .. *x* Long.
— 250^{m}. —— 312^{m}. — 373^{m}. —— 465^{m}.

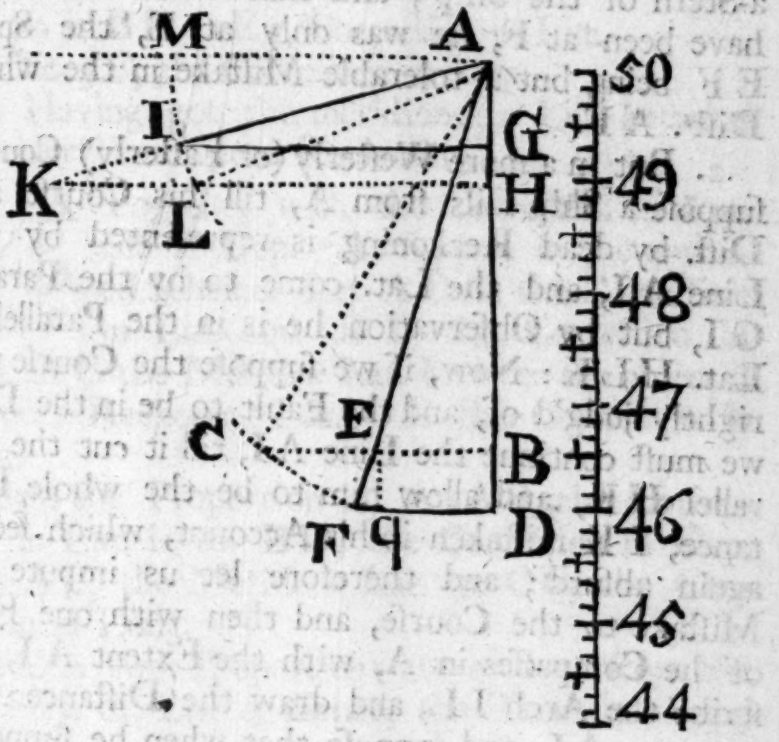
Or, —— ——————
To which add the —— } 7° : 45′ Weſt.
Long. of the *Lizard*, } 5 : 23 Weſt.
Long. Corrected, —— 13 : 08 W.
Which ſet down in your long Book accordingly.

2. And

2. And for a general Rule to correct the Reckoning on an Oblique Course, observe,

If your { more / less } than the Dep. the { more / less } Fault is most likely to be in { Log. or Dist Steerage, or Course. }

See the Scheme or Figure hereunder.



Demonstration.

Suppose a Ship sails within 5 or 6 Points of the Meridian South-westerly, till by Reckoning she is at C, or in the parallel of Lat. B C; but by Observation is found in the parallel of Lat. D F: Now, if I suppose the computed Distance A C to be right, sweep the Arch C F, till it cut the Parallel D F in F, and make A F equal to A C: Now, by this Means the Line A F is the Line described by the Ship's Motion; whereas, by

dead

dead Reckoning, we thought it had been the Line A C; but it ſeems improbable or abſurd to think that any ſhould be ſo far miſtaken in their Courſe as to ſteer from A to F, when he thought he had been ſteering from A to C; and therefore let us impute the Fault to the Diſtance: Suppoſing that the Miſtake lies there, and that when he thought he had ſteer'd from A to C, his Reckoning was a-Stern of the Ship; and that when he ſhould have been at F, he was only at E, the Space E F being but a tolerable Miſtake in the whole Diſt^{s}. A F.

2. But in a more Weſterly (or Eaſterly) Courſe, ſuppoſe a Ship ſails from A, till his Courſe and Diſt. by dead Reckoning is repreſented by the Line A I, and the Lat. come to by the Parallel G I, but by Obſervation he is in the Parallel of Lat. H L K: Now, if we ſuppoſe the Courſe was rightly judg'd of, and the Fault to be in the Diſt. we muſt continue the Line A I, till it cut the Parallel H K, and allow him to be the whole Diſtance, I K miſtaken in his Account, which ſeems again abſurd; and therefore let us impute the Miſtake to the Courſe, and then with one Foot of the Compaſſes in A, with the Extent A I, deſcribe the Arch I L, and draw the Diſtance A L equal to A I, and ſuppoſe that when he ſuppos'd he had ſail'd along the Line A I, he had indeed ſail'd along the Line A L, the Angle I A L being a much more tolerable Fault in the Courſe, than the Diſtance I K could be ſuppoſed in the Diſt.

Hence, and from the aforeſaid General Rule, when the Error is ſuppos'd to be in the Diſt. by the Log (as moſt Generally is, by different Perſons heaving of it, and other Reaſons) this Proportion ariſes for correcting your Reckoning by an Obſervation, *viz.*

As

As the total Northing, or Southing, (or dead Reckoning ✕ Lat.) is to total Eaſting or Weſting, (or dead Reckoning Merid. Diſt.) ſo is the Error in Northing or Southing, called the Correction in Lat. or the Difference between the Lat. by Reckoning and Obſervation, to the Error or Correction in Eaſting, or Weſting, or Merid. Diſt. For,

As A B dead Reckoning ✕ Lat.
Is to B E dead Reckoning Dep.
So is B D = E *q*, Correction in Lat.
To *q* F, the Correction in Dep.

2. Having got the meridional ✕ Lat. between the obſerv'd and dead Reckoning Lat.

Together with the Correction in Lat. and in Dep. As ſuppoſe in the annexed Scheme. Let A B be the Correction in Lat. and B D the Correction in Dep. A C the Merid. ✕ Lat. between the obſerv'd and dead Reckoning Lat. C E the Correction in Long.

Then the Proportion is, As A B, the Correction in Lat. is to B D, the Correction in Dep. So is A C, the Merid. ✕ Lat. to C E, the Correction in Long.

Which two Proportions are evident from the 4th *Prop.* of *Lib.* 6 *Euclid*, the Triangles being ſimilar.

Note, The dead Reckoning, ✕ Lat. and Dep. muſt be collected from the beginning of the Voyage, if it be the firſt Error (or Correction) otherwiſe from the laſt Error, or from the laſt Obſervation, to the Day of the preſent Error.

If in caſe your Courſe be far Eaſterly, or Weſterly, and you find an Error between the dead Reckoning Lat. and obſerved Lat. it is beſt to truſt to the obſerv'd Lat. and not meddle at all with the Departure, or ✕ Long. becauſe the Error is ſo ſmall; as in the foregoing Scheme, the true Departure

ture H L differs ſo little from the dead Reckoning Dep. G I, that it is not worth while to correct it.

Now, If you ſhould judge that there is an Error as much in the Courſe as in the Diſt. then you muſt part the Difference; as for Example.

If you think you have ſailed by the Rhumb-line A F, S. S. W. and to be arrived at E, in the Parallel of Lat. B E. and your Obſervation ſheweth, that you are in the Parallel of Lat. D F. Draw the Line E *q* parallel to a Meridian, and then take the Point *q* for the Place of your Ship; that is, take the obſerved Lat. A D and Dep. by Reckoning, B E = E *q*, to find the corected Courſe, Diſt. and Dep.

Again; if you have an Obſervation every Day or two, and find ſome Difference between your Obſervation and dead Reckoning Lat. 'tis beſt to judge well of the Courſe made good, and with that and the obſerved ✕ Lat. work your Day's Work by Caſe 2, *Mercator*'s Sailing.

To correct the dead Reckoning upon a North or South Courſe, when the dead Lat. differs from that obſerv'd.

You muſt correct the Ship's Place in the ſame Meridian, and in the obſerved Parallel.

Example.

Suppoſe a Ship ſail 80 Leagues South from A, till by my Reckoning, ſhe is in the Point B in Lat. 46°. but by Obſervation ſhe is in the Point D, in Lat 45° : 46′, which I muſt truſt to rather than by the reckoning Lat. The ſame is to be underſtood if you had ſailed North.

To correct your Reckoning, upon an Eaſt or Weſt Courſe, if there be an Error you cannot diſcover by your Obſervation, if any Current ſets with or againſt the Ship, therefore 'tis beſt to

alter your Courſe a little, that by the Diff. of Lat. you may diſcover the Error.

When you have ſail'd ſeveral Leagues or Miles Eaſt, or Weſt, and find by your Obſervation, that you have not been under that Parallel where your Reckoning places you, then your Reckoning muſt be corrected by your obſerved Difference of Lat. and Diſtance; as forExample.

Suppoſe a Ship ſails W. 150 Miles, from A, in the Lat. of 50, to M, and by Obſervation the Ship is found in the Lat. of 49° : 00′, then with one Foot of your Compaſſes in A, with the Diſt. A M, deſcribe the Arch M L, ſo ſhall L be the the Place of the Ship in the parallel Lat. of 49°: And here we have alſo the Diſt. and obſerved ✕ Lat. to find the corrected Courſe, Depart. *&c.*

Laſtly, and Generally, The Error lieth in the Log, or Diſtance; and this is that which moſt uſually makes the Difference between the obſerv'd Lat. and the Lat. by Reckoning: And herein are two Caſes.

Caſe 1. In North Lat. ſailing toward the North, and in South Lat. ſailing toward the South;

If the obſerv'd Lat. be the greater, then hath the Ship out-run the Reckoning; but if it be the leſſer, the Reckoning hath out-run the Ship,

Caſe 2. In North Lat. ſailing towards the South, and in South Lat. ſailing towards the North;

If the obſerved Lat. be the greater, then hath the Reckoning out-run the Ship; but if it be leſſer, the Ship hath out-run the Reckoning.

So that when the Ship hath out-run the Reckoning, then is the Reckoning too little, and it muſt be augmented;

But when the Reckoning hath out-run the Ship, then is the Reckoning too great, and muſt be leſſened; that is, the Correction in Departure muſt

be added to, or ſubtracted from the meridional Diſtance, according to the Caſes above;

And the Correction in Long. (according to the new way of counting it) if the Long. in, and its Correction, be both Eaſt or both Weſt, add; but one Eaſt, and the other Weſt, ſubtract; and the Longitude is corrected.

§. 3. *To work a Day's Log, or to keep account of a Ship's Way upon a Wind.*

A Ship (in the Sea Phraſe) is ſaid to ſail upon a Wind, when her Tacks are a-board, and her Yards ſharp Braced, and the Bowlines haled forward, and is commonly ſuppoſed to lie up within 6 Points of the Wind (tho' Yachts, Sloops, and Hoys, or Smacks *&c.* will lie much nearer to the Wind) a Ship's Lee-Way is counted according to the Sail ſhe carries, *viz.*

All Sails ſet, 1. Point.
Topſails, all Reefs taken in, and a great Sea, 1 ½ Point.
A Topſail taken in, 2.
Both Topſails taken in and a Sea, 3.
Try under Main-ſail and Mizen, 4.
Try under Main-ſail only, 5.
Under a Mizen only, 6.
Lying or Trying a Hull, all Sails furled. 7.

Theſe are the uſual Allowances for Lee-way, and by which we ſhall Work the following Examples: Nevertheleſs in Practice Lee-way muſt be allowed according to Judgment, for ſome Ships make more Lee-way than others, with the ſame Sail-ſet, *&c.*

And reſpect alſo muſt be had to the ſmoothneſs of the Water, or to the Sea's running high; and then the Allowance for Lee-way being rectified and adjuſted by ſetting the Ship's Wake by the Com-

Compaſs, or Quadrant of a Circle, which is uſually (or ought to be) placed on each Rail of the Ship's Quarter for that purpoſe.

To allow for the Lee-way, Starboard Tacks a-board, allow the Lee-way to the Left-hand of your Courſe by the Compaſs, but Larboard Tacks a-board towards the Right.

Therefore with Weſt Variation and Starboard Tacks a-board, the Sum of the Variation and Lee-way, is the Allowance to the Left-hand, to make your Courſe good from the Point the Ship lies up to by the Stem; but with Weſt Variation, and Larboard Tacks aboard: If the Variation is greater than the Lee-way, the Diff. muſt be counted to the Left-hand of your Courſe; if leſs, to the Right; if equal, you make your Courſe good by the Compaſs.

Explication.

1. If the Ship be upon a Wind, with her Starboard Tacks a-board, and Stem W. S. W. the Wind at N. W. 1 Point W^t. Variation and Topſails ſet. 1 Point Lee-way is allowed in this Caſe; her Courſe made good is S. W. but with her Starboard Tacks a-board, ſhe would make her Courſe good at N. N. E. becauſe her Lee-way and the Variation are equal: For the Variation being one Point W. the Ship lying up N. N. E. her Courſe allowing the Variation, is N. by E. but allowing 1 Point Lee-way from the Wind brings it again to N. N. E. All which plainly appears, if you lay the Chard of the Compaſs (foregoing) before you.

2. If the Wind blow hard and cauſe one Topſail to be handed or taken in, the Variation ſtill 1 Point Weſt, Starboard Tacks a-board, the Wind at N. W. Ship Capes, or lies up W. S. W. then allowing 2 Points Lee-way, her Courſe is S. W. by S. but with her Starboard Tacks N. E. by N.

3. If it blow ſo hard that both Topſails are taken in, and the Sea run high, and you allow 3 Points Lee-way; then in the Caſe above, her Courſe with her Starboard Tacks a-board, is S. S. W. and with her Larboard Tacks N. E.

4. If the Fore-ſail be furled, and ſhe try under a Main-ſail and Mizen, you allow 4 Points Lee-way, then in the Caſe above, her Courſe will be with her

Starboard } Tacks { S. by W.
Larboard } { N. E. by E.

5. If ſhe try under a Main-ſail only, and you allow 5 Points Lee-way, then in the Caſe above, her Courſe will be with her

Starboard } Tacks { South.
Larboard } { E. N. E.

6. But if ſhe try under a Mizen only, and you allow 6 Points Lee-way; then in the Caſe above her Courſe

Starboard } Tacks is { S. by E.
Larboard } { E. by N.

7. If ſhe be a-Hull, with all her Sails furl'd, and you allow 7 Points Lee-way, then in the Caſe above her Courſe on the

with { Starboard } Tack is { S. S. E.
{ Larboard } { Eaſt.

That is, with allowing 1 Point Weſt Variation in all theſe ſeven Examples.

8. If the Wind hath blown hard at N. W. and made a high Sea, the Ship ſtemming as before, W. S. W. but the Wind ſhifting to the South while the Sea continues to run high, it taking the Ship on

on the Lee-Bow, abates the Lee-way. Theſe Directions, with a little Practice, and conſideration of the Ship's Trim, Sail aboard, ſtreſs of Wind, and growth of the Sea, will ſo ſtrengthen our young Navigator's Judgment (for whoſe ſake I have taken this Pains) that he'll ſeldom fail of making a true allowance.

We ſhall proceed now to ſome particular Examples im working a Day's Log, the Ship being upon a Wind.

♄ (*or* Saturday) *March 9th* 1723.

H	K.	F	C	W	*Occurrences.*
1	4	3	W. S. W.	N. W.	*Variat.* ¾ Point W.
2	5	2	Mod.	and Fair.	
3	6	1		W.N.W.	This 24 Hours the
4	6	2			moſt part freſh Gales
5	6	—	S. S. W.	Weſt.	and Rain, with vari-
6	6	1			able Winds.
7	5	4	Freſh.	Gales.	
8	5	2	S.	W. S. W.	Courſe S. 12°: 15′ W.
9	5	1		Rain.	Diſt. —— 108m.
10	5	—			Southing 105m.
11	5	—			Weſting 23m.
12	4	3	S. S. E.	S. W.	Lat. *pr.* Dd. 44:01 N.
1	4	2		Fair.	Mer. Diſt. 335 W.
2	4	—			✕ Long. 32m. W.
3	4	2	Tackt.	S. by W.	Long. in 13°:40′ W.
4	5	—	W. by S.	Rain.	The *Lizard* bears
5	5	1			N°. 43° : 18l E.
6	5	3			Diſt. 162 Leagues.
7		2	S. S. W.	S. E.	
8	5	1			
9	5	2			
10	5	—	S°.	E. S. E.	
11	5	3			
12	5	1	Reeſt	Topſails.	

In this Day's Sailing, the Ship hath had her Starboard Tacks a-board, from 12 at Noon, till 2 in the Morning, the Topſails being ſet, I allow 1 Point Lee-way, and $\frac{1}{4}$ Point Weſt Variation, is 1 Point $\frac{1}{4}$ I muſt allow to the Left-hand of the Log Courſes during that Time: So that the Courſes corrected according to the former Directions, are (with the Diſt. ſailed on each, *viz.* S. W. $\frac{1}{4}$ W. 10^m. S. S. W. $\frac{1}{4}$ W. 12^m. S. $\frac{1}{4}$ W. 18^m. S by by E. $\frac{3}{4}$ E. 15^m. S. E. by S. $\frac{3}{4}$ E. 18. Then at 2 in the Morning the Ship tack'd to the Weſtward; therefore having her Larboard Tacks on Board till Noon, the variation $\frac{1}{4}$ Point Weſt abates the Lee-way to $\frac{1}{4}$ Point, which I allow to the Right-hand of the Log. Courſes; which makes them (when corrected) W. by S $\frac{1}{4}$ W. 18^m. S. S. W. $\frac{1}{4}$. W. 21^m. S°. $\frac{1}{4}$ W. 16^m. Theſe Courſes and Diſt. being collected in Order, and the Traverſe work'd as before taught, will give the Southing 105^m. Weſting 23^m. Courſe S. 12° : 15′ W. Diſt. 108^m.

		M.	*P.*
Lat. Yeſterday *per* Obſervat.	45 : 46′	3095	
× Lat. S°. ſub. —— ——	1 : 45		
Lat. *per* Acco^t to Day —	44 : 01	2947	
Meridional × Lat. —— ——		148	
Meridional Diſt. Yeſterday ——		312	W.
Weſting made to Day —— ——		23	
Meridional Diſt. to Day ——		335	W.
As × Lat. .. Dep. :: Mer. × Lat. to the × Long. —— ——	0° : 32′	W.	
Long. in Yeſterday Add ——	13 : 08	W.	
Long in to Day —— ——	13 : 40	W.	

From

From Lat. *Lizard* 49° : 56′ ſubt. Lat. in 44° : 0′ 1,
remains the ✕ of Lat. 5° : 55′ or 355 miles

As ✕ Lat. .. Merid. Diſt : : R .. T.C. 43° : 18′.
As S. C. .. R : : Mer. Diſt.. Diſt. .. 487 Miles.
Or 162 Leagues ——— So that the *Lizard* bears from the Ship N° 43° : 18′ E^{t}. Diſt. 162 Lg^{s}. Which Day's Work enter in your Log-Book accordingly.

☉ (or Sunday) *March* 10th, 1723.					
H	K	F	C.	W.	*Occurrences.*
1	5	1	S. by W.	S. E. by E.	Variation ½ P^{t}. W.
2	3	—	Handed	F. Topſail.	This 24 Hours
3	3	1			hard Gales of
4	3				Wind & thick ha-
5	2	4			zy Weather, and a
6	2	5			great Sea from the
7	2	3			S. E. Board.
8	2	2	S. S. W.	S. E.	Cour. S. 51°:20′ W.
9	2	3			Diſt. 57^{m}.
10	3	—	Handed	M. Topſ.	Southing 36^{m}.
11	2	1			Weſting 45^{m}
12	2	2			Lat. *per* Account
1	2	3			43° : 25′ N.
2	2	1	S.W. by S.	S. E. by S.	Mer. Diſt. 380^{m}
3	2	2			Weſt.
4	2	1			✕ Long. 62^{m} W.
5	2	1			Long. in 14° : 42′
6	2	1			Weſt.
7	2	3			D°. N. 44°:08′ E.
8	2	3	S. W.	S. S. E.	Diſt. 181 Leag^{s}.
9	2	4			
10	3	—	Reeſt	Courſes.	
11	3	1			
12	3	1			

In this Day's Motion, the Ship hath had on Board her Larboard Tacks. The firſt Hour her Topſails being ſet, but cloſe reeſt and a great Sea, I allow 1 ½ Point Lee-way, and Variation as (above) ½ Point Weſt, which abates the Lee-way to 1 Point: So that the firſt Courſe corrected is S. S. W. Diſt. 5^{m}. but ſeeing at 2 a Clock the Fore-Top-ſail was taken in, I allow on the aboveſaid (Log) Courſe 2 Points Lee-way, which makes the Courſe good with the Variation, S. S. W. ½ W. and the Diſt. by the Log till 8 a Clock, is 17^{m}.

The next Courſe is S. S. W. which with the ſame allowance corrected, is S. W. by S. ½ W. and the run from 8 to 10 a Clock is about 5 Miles; then at 10 a Clock the Main-Topſail was taken in, and the Ship under her 3 Courſes, *viz.* Fore-Sail, Main-Sail, and Mizen; therefore I allow 3 Points Lee-way on the ſaid S. S. W. Courſe, which with the abatement of ½ Point W^{t} Variation makes the Courſe corrected S. W. ½ W. and the Diſt. run from 10 till 2 in the Morning is 11 Miles.

The next Courſe is S. W. by S. which by the aboveſaid allowance makes it good at S. W. by S. ½ W. and the run from 2 a Clock till 8 is 13 Miles.

The next Courſe by the Log is S. W. which with the aboveſaid allowance corrected is W. S. W. ½ W. and the run from 8 in the Morning till Noon is 14 Miles.

So that the ſeveral Courſes (with the Diſtances) corrected or made good are, *viz.*
S. S. W. ½ W. 17 Miles. S. W. by S. ½ W. 5 Miles; S. W. ½ W. 11 Miles; S. W. by W. ½ W. 13 Miles; W. S. W. ½ W. 14

Which Traverſe being wrought, you'll find the Southing 36 Miles; Weſting 45 Miles; Courſe S°. 51° : 20′ W. Diſt. 57 Miles.

Lat.

		M.	P.
Lat. Yesterday ——	44° : 01′	—2947	
× Lat. Sub. ——	0 : 36		
Lat. to Day *per* Account	43 : 25	—2897	
Meridional × Lat. —— ——		50	
Merid. Dist. Yesterday		335^{m}	W.
Westing this 24 Hours ——		45	add.
Merid. Dist. to Day ——		38°	W.
As × Lat. .. Dep. :: Merid. ×. of			
Lat. .. × Long. 62^{m}. or		1° : 02′	W.
Long. in Yesterday, Add		13 : 40	W.
Longit. in to Day ——		14 : 42	W.

Lat. *Lizard* 49° : 56′ — Lat. in 43° : 25′
is equal to × Lat. 6° : 31′. or 391 Miles.

As × Lat. .. Dep. :: R .. Tang. Course.
——391^{m}——380^{m}——T. 45°—44° : 08′.

As S. C. .. R :: Dep. .. Dist.
— S. 44° : 8′ S. 90° 380^{m} 543 m. or 181. Legs.

So that the *Lizard* bears N°. 44° : 08′ East.
Dist. 181 Leagues.

All which Day's Work place in your Log-Book, as before.

D *March* 11th 1723.

H	K	F	C	W.	*Occurrences.*
1	3	6	up Fore	ſail	Variation. ½ Pt. W.
2		—	S. by W.	S. E. by E.	
3		—	Try un	der M. S.	Hard Storms of
4			and	Mizen	Wind, and thick ha-
5			S. by E.	E. by S.	zy Weather, with
6			reeft &	Ballaft.	ſome Rain, and a ve-
7			the Mi	zen.	ry great and hollow
8			Try un	der a	grown Sea, all this
9				Mainſail	24 Hours
10			S. S. E.	E.	
11				Rain.	Courſe S. 24°:34′ W.
12			up main	Sail.	Diſt. 38 Miles.
1			Try un	der a	Southing 35 Miles.
2			Mizen		Weſting 16 Miles.
3					Lat. *p. Ac.* 42°:50′ N.
4					Mer. Diſt. 396^{m} W.
5			E. S. E.	N. E.	✕ Long. 22^{m} W.
6			ſplit our	Mizen to	Long. in 15°:04′ W.
7			Pieces.		D°. N.° 42°:50′ E.
8			Try a	Hull.	Diſt. 194 Leagues.
9					
10					
11				Rain.	
12					

In this Day's Motion, the firſt Hour the Ship was under her Courſes, I allow 3 Points Lee-way; but the Variation ½ Point Weſt, being counter (to or) contrary to the Lee-way, it makes it but 2 Points ½: therefore the Courſe corrected is S. W. by S. ½ W. Diſt. 4 Miles; then at 1 haul'd up the Fore-ſail, and laid a Try under the Main-ſail and Mizen, till 8 a Clock, for which I allow 1 Mile an Hour for Drift, which is 7 Miles; and allowing

allowing 4 Points Lee-way, and the Variation as as before, for the 2 Courſes S. by W. and S. by E. it makes them S. W. ½ W. in 4 Ho. is 4 Miles; and S. S. W. ½ W. in 3 Hours more 3 Miles. Then at 8 a Clock hauld up the Mizen, and lay a-Try under the Main-ſail only till 12, for which I allow 1 ½ Mile Drift an Hour, makes 6 Miles Drift; and the Courſes S. by E. and S. S. E. corrected, with Variation and Lee-way allowed, (*viz.* ½ P^{t}. leſs 5 P^{ts} = 4 ½) is S. W. by S. ½ W. from 8 to 9 a Clock 1 Mile; and S. S. W. ½ W. in 3 Hours, 3 Miles; then at 12 haul'd up the Main-ſail, and ſet the Mizen only till 8 in the Morning, for which I allow 2 Miles an Hour Drift, and 6 Points Lee-way, with the Variation, as above, makes the Courſes laid up S. S. E. to be S. W. by S. ½ W. from 12 to 5 a Clock 10 Miles; and the E. S. E. Courſe to be S. ½ E. in 3 Hours Drift more, 6 Miles. —— Then at 8 in the Morning the Storm and Tempeſt being ſo violent as to ſplit the Mizen (Sail) to Pieces, we lay a Try a Hull, (or under the bare Poles as the Sea Phraſe is) till 12 at Noon; for which I allow 2 ½ Miles Drift, an Hour, and the Lee-way 7 Points, and the Variation as above makes the E. S. E. Courſe corrected, with 6 ½ Points, S. ½ W. and the Drift on it in 4 Hours, 10 Miles.

So that the ſeveral Courſes corrected by Judgment, with their Diſtances, are, *viz.*

S. W. by S. ½ W. 4^{m}, S. W. ½ W 4^{m}.
S. S. W. ½ W. 3^{m}.— S. W. by S. ½ W. 1^{m}.
S. S. W. ½ W. 3^{m}. S. W. by S. ½ W. 10^{m}.
S. ½ E. 6^{m} ——— S. ½ W. 10^{m}. ——.

Theſe 8 Courſes may be reduced to 5, by putting the ſeveral Diſtances on the ſame Courſes together; for the firſt, fourth, and 6th Courſes are the

the ſame, and the Diſtances added together, 41. and 10 make S. W. by S. ½ W. 15 Miles.

The third and 5th Courſes are the ſame; and the Diſtances put together are S. S. W. ½ 6 Miles.

The ſecond, ſeventh and eighth Courſes are, S. W. ½ W. 4m. S. ½ E. 6m. S. ½ W. 10m. Which Traverſe wrought makes the Southing 35m. Weſting 16m. Courſe S. 24° : 34′ W. Diſt. 380 Miles

		M. P.
Lat. Yeſterday,	43° : 25′ ——	2897
x Lat. ſubt.	00 : 35	
Lat. *per* Account	42 : 50 —	2849
Merid. *x* Lat.		48
Merid Diſt. Yeſterday, ——		380m W.
Weſting to Day, Add ——		16
Merid. Diſt. to day ——		396 W.

As *x* Lat. .. Dep. :: Merid. *x* of Lat. .. *x* Long. —— } 0° : 22′ W.

Long. in Yeſterday add 14 : 42 W.

Long. in to day, —— —— 15 : 04 W.

Lat. *Lizard* 49° : 56′ — 42° : 50′ = 7° : 06′ Or 426 Miles the whole Southing, or *x* Lat. from the Lizard.

As *x* Lat. .. Dep. :: R. .. L. Courſe S. 42° : 50′ W.
As S. C. .. R. :: Mer. Diſts. .. Diſts. 194 Lgs.

Therefore the *Lizard* bears from the Ship North 42° : 50′ E. Diſtance 194 Leagues. Then this 24 Hours Work enter alſo in your Log-Book, and you've done.

8 *March*

81 *March* 12. 1723. Log hove every 2 Hours.

H	K	F	C	W.	*Occurrences.*
	ſet	f. ſail	S. S. W.	N. E.	*Variat.* 2 Point W.
2	5	3	Freſh	Gales.	This 24 hours the
4	5	5		N.E.b. N.	firſt and middle
6	6	3			Part freſh Gales
8	6	5	ſet fore-	Topſail.	and cloſe Weather.
10	7	3			The latter Mod.
12	7	4		N. E.	and Fair at ½ p^{t}.
2	7	5	Set	Main-ſail.	12 at Noon, bent
4	8	1	S. b. W.	N.E. by E.	a new Mizen, and
6	8	3	Set M.	Top-ſail.	bore away.
8	9	———	Mod.	and Fair.	⊙ Z.Di. 39°:56′ S.
10	9	2	S.b.W. ½	Weſt.	⊙ Dec. 0:28 N^{o}.
12	9	4	ſet Miz.	Top-ſail.	———
					L. *p. Ob.* 40:24 N°.

Courſe S. 12° : 50′ W. Diſt. 181 Miles.
Southing 176^{m}. Weſting 40 Miles.
Lat. *per* D^{d}. 39° : 54′. N.
Merid. Diſt. correct. 446 Miles. W.
Long. correct 16° : 10′ Weſt.
D°. N°. 38° E. Diſt. 242 Lgs.

In this Day's Sail the Ship hath gone with a quarter (or fair) Wind, and a great Sea from the N. E. board following the Ship, and therefore we ſhall allow 1 Mile in 10 more of the Diſt^{s}. for the Sea heaving home the Log; and becauſe the Log was heav'd but once in two Hours, double the Diſt. run on each Courſe:

Then to correct the Courſes, with allowance of ½ Point Weſt Variation (as above) only toward the Leſt. The firſt Courſe corrected is S. by W. ½ W and Diſt. 43 Knots; doubled, taking in the double of 28 Fathom, *viz.* 56, or 8 Knots, makes

makes 94 Miles, to which I add 9 Miles more for heaving back the Log, makes 103 Miles, the Diſt. run on this firſt Courſe till 8 in the Morning. The ſame being allow'd in the other two Courſes, makes them S. ½ W. 56^{m} and S. *b.* W. 22^{m}. this Traverſe ſolv'd gives the Southing 176^{m}. Weſting 40 Miles, Courſe S. 12° : 50′ W. Diſt. 181 Miles.

		Mer. Parts
Lat. yeſterday —	42° : 50′ —	
Southing Subt. —	2 : 56 = 176^{m}.	2849
Lat. *per* Dead.	39 : 54 — —	2615
Merd. *x.* Lat. — — —		234^{m}.
Merd. Diſt. yeſterday — — —		396^{m}. W.
Weſting to Day add. — — —		40
Merd. Diſt. *per* Account — —		436 W.

As *x.* Lat. Depr. :: Merd. *x.* Lat. .. *x.* Long.

	00° : 53 W.
Long. in yeſterday add. — —	15 : 04 W.
Long. *per* Account — —	15 : 57 W.

But ſeeing, by a good Obſervation, to Day I find the Ship in Lat. 40° : 24′ N. whereas by my Account of Dead-Reckoning, I am in the Lat. of 39° : 54′. So that my Reckoning hath out-run, or is a Head of the Ship 30 Miles; ſo that I may ſuppoſe there hath been ſome current, or that I have not exactly computed the Courſe and Diſt. by the Log, but rather ſhall conclude, that for two or three Days laſt paſt, we have had a great Sea, from the Eaſtern, and S. E. board, which hath ſet the Ship more to the N W. than *per* Judgment, therefore, im-

imputing the Error to the Dist. becauſe my Southing is more than the Weſting, ſince laſt Day of Correction, *March* 8. where my Meridian Dist. was 312m. W. and to Day is 436, the Difference is 124m. the Dead-Reckoning Depr. then.

Lat. *March* 8. was *per* Ob.	45° : 4′ 6
Lat. *per* Account to Day.	39 : 54
	5 : 52
	60
Dd. reckoning *x.* Lat.	352 Miles.

			M. P.
Lat. *per.*	Ob.	40° : 24′	— 2654
	Dd. to Day.	39 : 54	— 2615
Error in Lat. 30m. and in M. *x* Lat.			— 39

Merid. *x.* Lat. between the obſerv'd and reckoning Lat. is 39m.

Then the Proportion is;

As Dd. reckoning *x.* Lat.	352m.
Is to Dd. reckoning Depr.	124
So is Correction in Lat.	30.
To Correction in Depr.	10.
And as Correction in Lat.	30m.
Is to correction in Depr.	10m.
So is Merd. *x.* Lat.	39m.
To Correction in Long.	13m.
Merd. Dist. *per* Account	436 W.
Correction in Depr. Add.	10 W.
Merd. Dist. corrected	446 W.

Long.

Long. in *per* Account	15° : 57′ W.
Correction in Long. add.	0 : 13 W.
Long. corrected	16 : 10 W.
Lat. of the Lizard	49° : 5′6 N.
Lat. *per* Obſervat. to Day	40 : 24 N.
x. Lat. S°.iy. from the *Lizard.*	9 : 32 or, 572 Miles.

As *x.* Lat. .. Depr. :: R .. T. C. — 572m—446m — T. 45.° — S. —— 38° : W. As S. C. Depr. :: R .. Diſt. — S. 38° — 446m — S. 90. — 726 or 242 Leagues. So that the *Lizard* bears.

N. 38° E. diſtant from the Ship 242 Leagues which with the corrected Merd. Diſt. and Long. *&c.* I place in my Log-Book; as you ſee.

Thus I think I have ſufficiently ſhewn our young Mariner how to work a Day's Log, when the Ship is by, or Large, (that is, with a foul or fair Wind) and in all Weathers; and the Method of making Allowances for Variation of the Compaſs, Currents, Leeway, Drift, Growth of Sea, and other known Impediments; and alſo given him demonſtrative Rules and practical Examples, for rational Corrections, when he finds an Error in his Reckoning, *&c.* with other experienced Rules and Methods, which hitherto hath been wanting in Authors, and the Generality of Teachers of Navigation. I ſhall draw to a Concluſion of this Part; ſuppoſing, if the Learner underſtands what is here laid down, 'twill be as uſefull to him as if I had inſerted (as I thought to have done) an actual Run, from the *Lizard* to *Lisbon*, *Madera*, &c. which would both have augmented the Book and its Price; the

Sheets

Sheets having already exceeded my deſigned Brevity, by endeavouring to make every thing, (neceſſary in the Theory and Practice of this noble and uſeful Art) as plain, perſpicuous, and intelligible as poſſible, to the moſt indifferent or meaneſt Capacity.

I would further here inform our young Artiſt, that its both uſual, and alſo uſeful, when you ſail from *England* far to the South-weſtward, as for Inſtance; to *Barbadoes*, in the Weſt-*Indies*, to ſteer ſomething to the Southward of your direct Courſe, becauſe 1ſt; you will ſooner have the Advantage of a Trade, (or fair) Wind, and 2*ly*, bring your Ship in a Parallel, or Eaſt and Weſt Courſe to the Iſland bound to; and ſo by keeping your Ship, as nearly in that Parallel, as you can by your Obſervation, (or Dead-Reckoning) that you may more certainly hit, or fall in with the Iſland.

And in coming from the S. Weſtward towards *England*: As for Inſtance, from the abovelaid Iſland, you ſail, to the Northward of your direct Courſe, that you may ſooner get into a variable Wind's way, and ſo make the beſt Advantage to gain your Port in the ſhorteſt Time; always diligently and ſtrictly looking out for the Land, before you approach too near it by your reckoning.

Now if at any Day at Noon (when your Day's Run is work'd) you would know how *Madera*, or ſuch a head Land you draw near or are bound to, bears from the Ship, you have always given the Lat. and Long. your Ship is in, and the Lat. and Long. of the ſaid Place (found in the Tables of Lat. and Long. or Chart) to find the Courſe and Diſt. by the firſt Caſe of *Mercator*'s or mid. Lat. Sailing.

Or if you would find the Point in the *Mercator*'s Chart, that repreſents the Ships Place; or to find the Bearings and Diſt. from the Ship to ſuch or ſuch head Land or Place, you may find the ſame, by the Directions of the uſe of *Mercator*'s Chart, before *Mercator*'s Sailing, Page 95, and 96. foregoing.

5. The preceeding Log-Book may indifferently ſerve both for Log-Book and Journal, together, according to the *India*, or Merchant-Ships Form; — but we ſhall ſhew how a Journal is kept, according to the Form of the Royal Navy. — In which Method the foreſaid Log-Book is to repreſent the Waſte-Book in Accounts; but the Journal is to repreſent the Ledger, or Fair-Book, and ought to be a Folio Book, rul'd and titled as here under the left Side of each Folio, for the Day of the Month, Week, Winds, Courſe, Diſt. Lat. Long. and Bearings, and Diſt. of head Lands, *&c.* The right Side of each Folio is to contain the Winds and Weather, and all remarkable Occurrences, that happens in the whole Voyage. In the firſt Page of your Journal, write the Title thereof thus;

A Journal of a Voyage (by God's Aſſiſtance) in his Majeſties Ship, C. *Captain* A. B. *Commander.*

From the *Lizard* in { Lat. 49° : 56′ N. / Long. 5 : 23 W. } to the Iſland *Madera* in { Lat. 32° : 17′ N°. / Long. 17 : 22 W.

The Courſe from the *Lizard* is S°. 27° : 09′ W.
Diſt. in that Rhomb. 397 Leagues,
Merd. Diſt. or Weſting 9° : 03′
x. Long. —— —— —— 12° : 08′ W.
Kept by *H. K.* —— —— ——)
Commencing *March* 5. 1723.

But if in a Merchant-Ship, leave out the two Words his Majeſties; and write in their room, in the good Ship, *C.* &c

Then every Day at Noon transfer or poſt the Days Work into the Journal, in manner following, which is a Journal of eight Days, as taken from the foregoing Log-Book.

W.

W. D. 1723.	M. D.	Winds *per* Compass	Course Corrected	Dif in M.	Lat. Corrected	Long. Corrected	Merid. Dift. and bearing, and Dif. of head Lands at Noon.
March		NNW. N *b* W.					Merid. Dift. 68m. W. the *Lizard*, at Noon, bears
♂	5	NW *b* N. NNW.	S. : 49 : 49 : W.	90	48° : 49' N.	7° : 07 W.	N. 49 : 14' E. Dift. 30 Leagues.
☿	6	E NE.	West.	136	Obs. 48° : 47' N.	10° : 33 W	Merid. Dift. 204m. W. D°. N°. 71° : 49' E. Dift. 72 L.
♃	7	NE. to N *b* E. back to NE *b* E.	S. 31 : 22' W.	102	47° : 20' N	11° : 52' W.	Merid. Dift. 257m. W. D°. N°. 58° : 45' E. Dift. 100 Ls.

Remark-

Remarkable Occurrences, on board his Majeſties Ship C. *from the* Lizard *towards* Madera.

March 5. 1723.

THIS 24 Hours the firſt and middle Part, freſh Gailes, cloſe Weather, and ſometimes Rain, the latter part moderate and fair. Yeſterday at 6, *P. M.* the *Lizard* Point bore N. N. W. Diſt. about 5 Leagues, from which I take my Departure bound to *Madera*, in company with three more Merchant Ships at 8 A. M. ſtowed our Anchors and hoiſted in our Long-Boat. Courſe, Diſt. Lat. Long. *&c.* as *per* Columns.

March 6.

This 24 Hours freſh Gailes of Wind and fair Weather, and a great Sea from the eaſtern Board. This A. M. obſerv'd by an Amplitude at Sun-riſing and found the Variation, about 11°. *Weſt.*

March 7.

This 24 Hours cloſe Weather with ſome Rain, freſh Gailes of Wind and Variable, ſometime calm. A great Sea from the N. E. Board made Trial of the Current, and found it to ſet E. N. E. 1 ½ Mile an Hour.

W. D.	M. D. 1723.	Winds per Compass	Course Corrected	Dist. in M.	Lat. Corrected	Long. Corrected	Merid. Dist. and bearing, and Dist. of Head Lands last seen.
		N.E. E. N.E. N.E.*b*N. N. E.	S 40°.15 W.				Merid. Dist. 312m. W. D°.
♀	8			104	Obs. 45° : 46′	13°:08 W.	N°. 51° : 21′ E. Dist. 133 Leagues.
♄	9	N. W. to E. S. E.	S. 12° : 15′ W.	108	44° : 01′	13° : 40 W.	Merid. Dist. 335 W. D° N. 4°3 : 18′ E. Dist. 162 Lgs.
☉	10	S. E.*b*.E. to S. S. E.	S. 51° 20′ W.	57	43° : 25′	14 : 42 W	Merid. Dist. 380m. W. D°. N. 44° : 18 E. Dist. 181 Lgs.
☽	11	S.E.*b*.E. to E. and N. E.	S. 24° : 34′ W.	38	42° : 50′	15 : 4 W.	Merd Dist. 396m. W. D°. bears N. 42° : 50′ E. Dist. 194 Lgs.
♂	12	N E. N.E.*b*E.	S. 12° : 50′ W.	18	Obs. 40° : 24′	16° : 10′ W.	Merid. Dist. 446m. D° N. 38d. E. Dist. 242 Lgs.

This

Remarkable Occurrences on Board the C. *March* 8.

This 24 Hours moderate Gailes and fair Weather at 4 *P. M.* ſpoke with a *Briſtol*-Galley, that came from *Leghorn*, bound for *London*. By a good Obſervation to Day, I find a Help to the Southward 25 Miles, with reſpect to the South-Weſtern Sea; ſo that my Merid. Diſt. and Long. corrected, is, as *per* Columns.

March 9.

This 24 Hours the moſt Part freſh Gailes, and Rain, with variable Winds.

March 10.

This 24 Hours hard Gailes of Wind, and thick haizy Weather, and a great Sea from the S. E. Board at 2 *P. M.* handed Fore-Topſail, at 10 D°. handed Main-Topſail, and at 10 A. M. reeſt Courſes.

March 11.

This 24 Hours hard Storms of Wind, and thick haizy Weather, with a very hallow grown Sea from the S. E. Board, at 1 *P. M.* up Foreſail; try under Mainſail and Mizen, at 6 D°. reeſt and ballaſt the Mizon, try under a Mainſail; at 12 at Night, up Mainſail, try under a Mizen; at 6 A. M. ſplit the Mizen to pieces, try a Hull.

March 12.

This 24 Hours freſh Gailes and fair Weather, at ½ pt. 12 at Noon bent a Mizen, bore away and made Sail, ſteering our proper Courſe.

For the Sake of the Curious, I have invented an Inſtrument hereunder which I call the *Nautical Medal:* Or, *Navigator's Pocket-Piece.* By which you may (without any Burthen to the Memory) work a Day's Work by the Pen, and Square-Root, as we have ſhew'd in Method 3 of *Plain-Sailing.* This Pocket-Piece is eaſily underſtood, for on one Side you have the Natural Sines, or given Numbers to every Point, and ¼ Point of the Comp. ſtanding to the Right-hand of the ſaid Points or Quarters; together with brief Rules for working *Pl. Sailing* and Mid. Lat. And on the other Side you have, (for more exactneſs) the given Numbers or Sines, to every Degree of the Quadrant. Theſe circular Pieces may be cut out, and paſted on each ſide a round, ſmooth, and thin Piece of Wood, and then are fit for (and will take up but little more Room than a Crown Piece in) the Pocket. The Uſe whereof altho' we have already ſhewn in *Meth.* 3 *Plain-Sailing*; yet for the Learner's Benefit, ſhall work by it the firſt Day's Log foregoing.

Example.

The Courſes there (corrected) with their Diſtances, are, *viz*

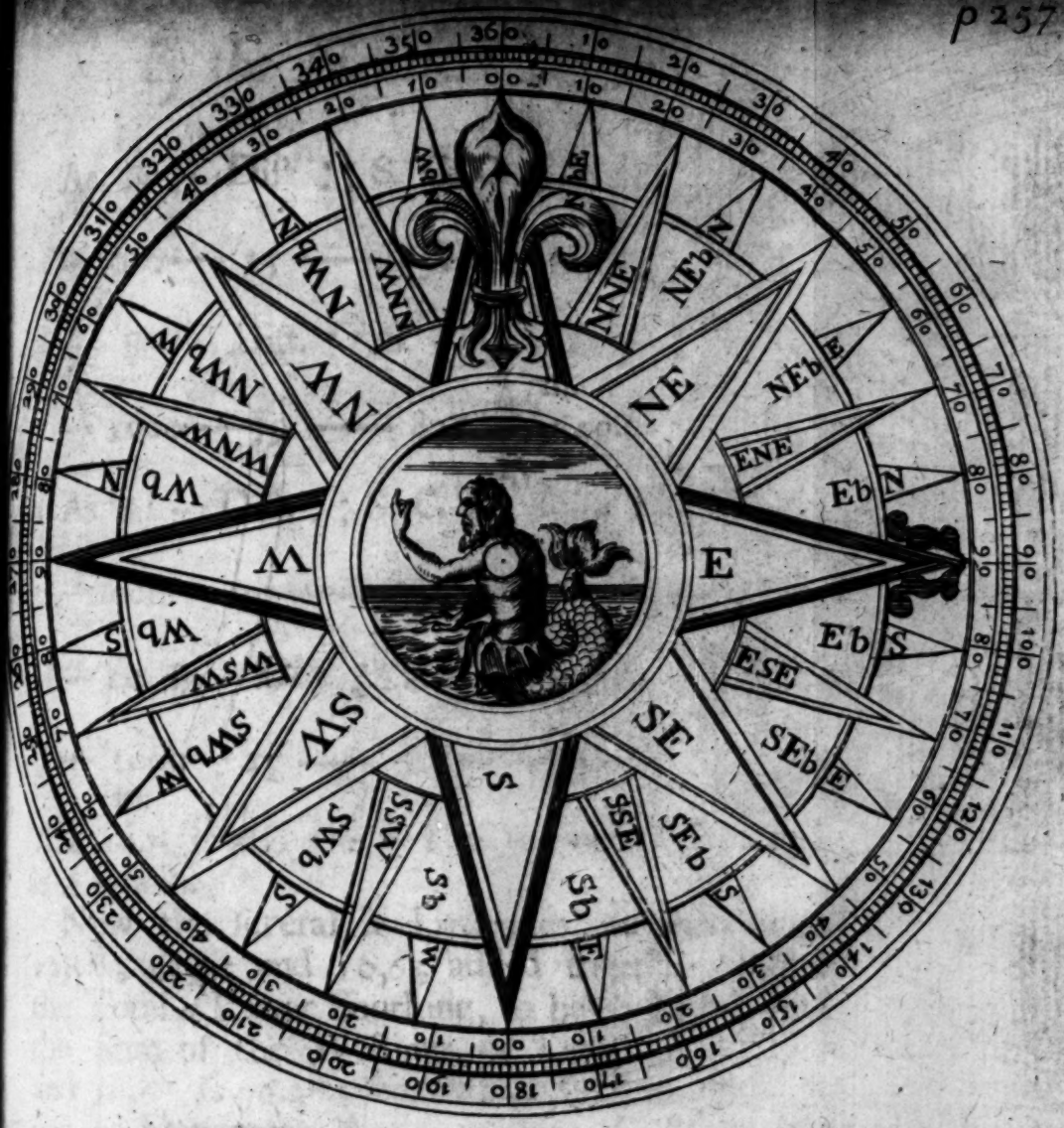
S. E. by S. 15^{m}. S. W. by W. 79^{m}. S. W. 15^{m}.

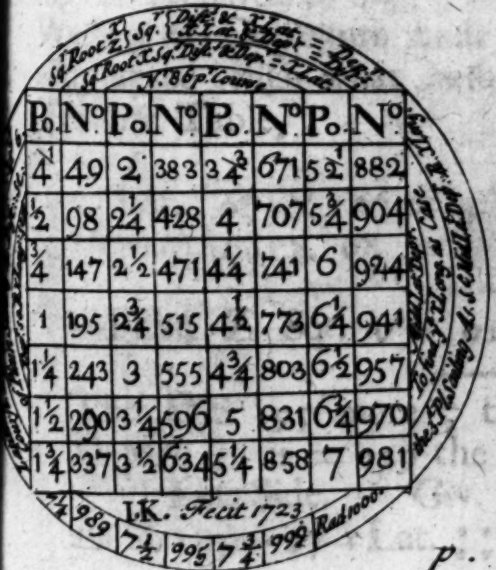
That is { 1, 2, 3 } Points whoſe Numbers on the Piece are, { 555. 831. 707.

Then,

			P.		
As R	.. Diſt.	::	S. C. 3	..	Dep^{r}.
	m.				m.
—1000—	15.	——	555	——	8,325.

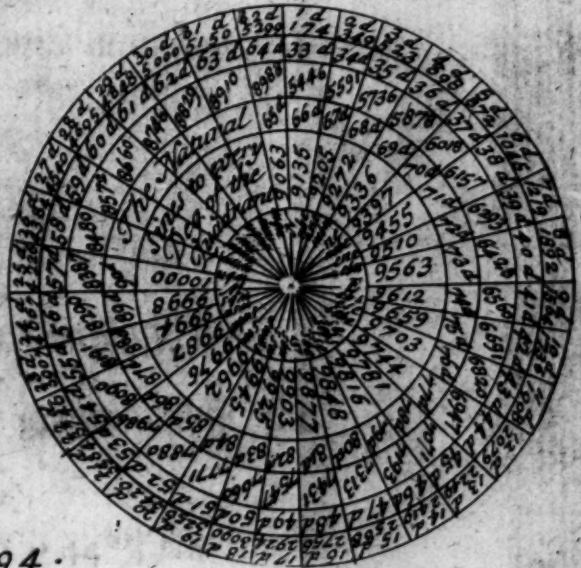
As





P.	N°	P.	N°	P.	N°	P.	N°
¼	49	2	383	3 ¼	671	5 ½	882
½	98	2 ¼	428	4	707	5 ¾	904
¾	147	2 ½	471	4 ¼	741	6	924
1	195	2 ¾	515	4 ½	773	6 ¼	941
1 ¼	243	3	555	4 ¾	803	6 ½	957
1 ½	290	3 ¼	596	5	831	6 ¾	970
1 ¾	337	3 ½	634	5 ¼	858	7	981
2	383	3 ¾	671	5 ½	882	7 ¼	989
2 ¼	428	4	707	5 ¾	904	7 ½	995
2 ½	471	4 ¼	741	6	924	7 ¾	998

I.K. Fecit 1723



P.

As R .. Dist :: S. C. C. 5 * Lat.

m.

—1000— 15 —— 831 ——12,465.

P.

As R .. Dist. :: S. C. 5 .. Dep.

m.

— 1000——79 —— 831 65,649.

P.

As R .. Dist. :: S. C. C. 3 .. * Lat.

m.

—1000——79 ——555——43.845.

P.

— As R .. Dist. :: S. C. 4 .. Dep.

— 1000— 15 —— 707——10,6.

m.

And 10,6 is also the * Lat. because the Course 4 Points.

Now the several * Latitudes, or Southings 2,5^{m}; 43,9; and 10,6; added together, makes the Total * Lat. or Southing, to be 67 Miles. And the Sum of the Westings, or Departures, 65,7^{m} and 10,6^{m} is 76.3^{m}; from which subtract the Easting, or Departure, 8.325, remains 68 Miles the Westing or Departure made; both of which exactly agree with what before was found by the Traverse Table,

* Lat. 67 × 67 = 4489 Sq^{r}. * Lat.
Depaart. 68 × 68 = 4624 Sq^{r}. Depart.

—From Z Sq^{r}. $\sqrt{^{2}}$ 9113 (= 95 Dist.

The Dist^{s} 95 more $\frac{1}{2}$ the greater Side the Depart. 34 is = 129 the Z.

Less Side. Giv. N^{r}.

As Z 129 .. 67 * Lat. :: 86 .. 44° $\frac{1}{2}$, the Angle opposite

oppoſite to the leſſer Side; which being the ✕ Lat. 'tis the Comp. of the Courſe: Therefore from 90° : 00′, take 44° : 30′, remains 45° : 30′, the Courſe South-weſterly.

Lat. { Lizard } 49° : 56′ —— 1° : 07 = 48° : 49′
{ in } 48 : 49

Courſe S^th-W^ly. ——

Z = 98 : 45

½ Z 49 : 22 Mid. Lat.
Subt. from 90 : 00

Remains 40 : 38 S. C. Midd. Lat.

but we ſhall take it for 41°. Whoſe Natural Sine (on that ſide of the Piece the whole Degrees are on) is 6560, which becauſe the Natural Sine is four Figures, the Radius muſt be 10000. Therefore ſay,

As S C. Mid. Lat. .. Dep. :: R .. ✕ Long.
—N.S. 6560 —— 68^m —1,0000—103, 65^m.

Or nearly 104^m —— or 1° : 44′ W. which added to 5 : 23′ W. the Long. of the *Lizard*, makes 07° : 07′ Weſt, the Long. the Ship is in.

So that the Courſe is S°. 45 : 30′ W.
Diſt. 95^m. Southing 67^m. Weſting 68^m.
Lat. in 48° : 49′ N. Merid. Diſt. 68^m. W.
✕ Long. 104^m W. Long. in 07° : 07′ Weſt.
And the *Lizard* bears N°. 45 : 30′ Eaſt.

Diſt. 95^m. or 32 Leagues very near; agreeing with the Traverſe-Tables, Logarithms, or *Gunter*'s Scale, and almoſt as expeditiouſly perſormed, by thoſe that can readily multiply and divide, and extract the Square Root, (which extraction may be taught and learn'd in half an Hour, by any Perſon that underſtands Diviſion): And as for the Proportions in working the Traverſe of the Day's Work, the firſt Number in the Proportions

portions you ſee (is Radius) 1,000 (or 1,0000); therefore you've nothing to do but multiply the ſecond and third Numbers together, and cut off from the Product three Figures, or four, (as many as there are Cyphers in the firſt Number) and the Remainder to the Left-hand is the Miles of the Departure, or ✕ Lat. and thoſe to the Righthand ſo cut off are the Decimal Parts of a Mile. ——— So in finding the ✕ Long. you need only annex four Cyphers to the Right-hand of the ſecond Number in the Proportion, and divide it by the firſt Number, the Quotient exhibits the Miles, and the Remainder the Decimal Parts of a Mile for the ✕ Long.

Secondly, We ſhall alſo work that uſeful Caſe in Navigation, where there is given the ✕ Long. and ✕. Lat. to find the Courſe, Diſt. and Dep.

Example.

What's the Courſe, Diſt. and Weſting from the *Lizard* to *Madera*.?

Preparation.

Lizard	in	49° : 56′ N°.	Long.	5° : 23′ W.
Madera	L.	32 : 17 N.		17 : 22 W.
✕ Lat. =		17 : 39 or 1059m.		11 : 59
	Z	82 : 13		60
½ Z & Md. Lat.		41 : 06	✕ Long.	719 Miles.
		90 : 00		
S. C. Md. Lat.		48 : 54.		

For which I ſhall take 49°. whoſe Natural Sine on the Piece is, 7547.

1. Then,

1. Then, as Case 3d. of *Plain Sailing*.

As R :: ✕ Long. :: S. C. Mid. Lat. :: Dep.
=10000 719^{m} —— 7547 —— 542,6293
Or near 543 Miles.

2. As the 6th Case of *Plain Sailing*.

✕ Lat. 1059 × 1059 = 1121481 Sq^{r}. ✕ Lat.
Dep. 543 × 543 = 294829 Sq^{r}. Dep.

Sq^{r}. $\sqrt[2]{}$ 1416310 (=110^{m}. Or 397 Leagues.

Dist. 1190 + ½ ✕ Lat. 529 = 1719 the Z.
Z Dep. G. N.
As 1719 .. 543 :: 86 .. 27° : 09′, *i.e.* the Course is S. 27 : 09. W. Dist. 397 Lgs.
Dep. Meridional Dist. or Westing, 111 Leagues, exactly agreeing with the Logarithmetick Solution thereof, as you may prove.

Note, To bring out the odd Minutes of the Angle for the Course in the last Proportion, multiply the last Remainder after Division by 60, (the Minutes of a Degree) and divide that Product by the same Divisor, the Quote gives the Minutes required.

Thus may the curious Learner work a Day's Log, or keep a Sea Journal by any, or all the other Methods by the Pen, that we have shewn in *Plain Sailing*, and made reference to in *Mercator*'s Sailing, which I leave to the Industry, and Improvement of our young Student.

And

And thus having finiſhed what I hope may (if duly ſtudied in the Theory, and carefully applied in the Practice) bring the diligent Learner to be a compleat Artiſt in this famous Art of Navigation, which has for its Hand-maids or Attendants, no leſs than Three out of Seven; nay, I might have ſaid, all the Mathematical Liberal Sciences; I ſhall here conclude in alluſion to a Circle and Triangle, the moſt excellent of all Geometrical Figures, and the Principal Figures alſo in Navigation and Aſtronomy: I ſay in alluſion to the Circle, the Emblem of Eternity, and the Triangle of the Tri-une Deity, the Trinity in Unity and Unity in Trinity, who created the Heavens, Earth, Sea, and all Things therein of Nothing, in Number, Weight, and Meaſure.

To whom be all the Glory, and Honour, and Adoration, *in Sæcula Sæculorum.* Amen.

The end of the PRACTICAL NAVIGATION.

The Conclusion.

O Thou Urania, *thou that now haſt brought*
Our Ship to Harbour ſafe, and richly fraught;
Tho' Æolus *his bluſtring Gales did ſend,*
And foaming Billows high the Skies did rend:
The bluſtring Storms, and Thunder loud did roar,
And Darkneſs grim oppreſs'd our Souls all o'er,
So that we could not view the Stars, nor Sky,
Nor Sun, nor Moon, nay Earth could not eſpy:
Yet by thy Art, ſuch Safety we did find
Tho' roughly toſs'd by raging Seas and Wind;
As at the laſt a Harbour ſafe did gain.
Rejecting Fears, we quite caſt off our Pain.
When Seas are calm, and Winds more ſerene be,
Then we again will put our Ship to Sea.
That when refreſh'd, we farther may deſcry
And ſearch into this Art *and* Mystery.

ERRATA.

PROEME, Page 5, line 33. for 1697, read 1597. p. xiii, l. 16. for South, r. North. and in the ſame, l. 18. for North, r. South.

Body of the Book, p. 29, l. 32. r. No. 6. p. 29. l. 1. dele three. p. 38, l. 25 & 30, r. Difference. p. 40, l. 16 & 18, r. Difference. p. 48, l. 16, r. 4. p. 49. l. 13, r. 1. p. 56, l. 30 & 31, r. Diſtance. p, 57, l. 1. r. Difference. ibid. l. 18, r. Diſtance. ibid. l. 24, r. Diſtance. p. 58, l. 3 & 29, r. Diſtance. ibid. p. l. 14, put Dep. 55.6. p. 59, l. 17, r. No. 7. p. 60, l. 5, r. Diſtance. ibid. l. 12, r. Diſtance and Difference of Latitude. p. 61, l. 1. l. 2 & 9, r. Diſtance. ibid. l. 19, r. No. 16. p. 63, running Title, r. Method 4th. p. 64. l. 4, r. Number 8. ibid. l. 17, r. the Square Root of the Difference of the Squares, of the Diſtance and Departure. p. 66, l. 21, for $\frac{2}{2}$ r. $\frac{1}{2}$. p. 70. l. 7, for S. r. quote. p. 72, l. 15, r. 59.4. p. 74, l. 17, for Treatiſe, r. Section. p. 76, l. 22, ace r. Caſe. p. 95, l. 3, are r. both. *ib.* l. 29. r. 114. p. 99, l. 13, r. Difference. *ib.* l. 22, r. Compaſſes. p. 114, l. 24, r. x. Longit. p. 133, l. 21. r. with. p. 144, l. 21, for S. r. ſ. p. 161, l. 34, for Log. to, r. Log. ſhe muſt. p. 163, l. 30, r. Windward for. p. 168, l. 6, 5, $\frac{1}{2}$ r. 5 $\frac{1}{2}$ Points. *ibid.* FA. r. F.A.G. *ibid.* l. 7, 78°, r. 48° *ibid.* l. 29, 67° = 67′ : 25, r. 6° : 25′. p. 169, l. 5, r. Diſtance. p. 172, l. 12, r. Diſtance. p. 173, l. 7. r. Sign. *ibid.* r. Diſtance. p. 175, l. 13, r. Aſcenſional. p. 190, l. 1 for If the, r. If in the p. 195, l. 4 and to, r. and added to. p. 201, l. 15, for 10°, r. 100°. p. 203, l. 18, for 9th, r. 19th. p. 206. l. 35, for Long, r. Log.

Nemo

Nemo Sine Crimine Vivit.

MEnd (gentle Reader) what has 'ſcap'd amiſs;
And then it matters not whoſe Fault it is:
The Printer ſins, I ſin much like the reſt,
And all Men ſin ſince Adam *firſt tranſgreſs'd:*
Yet here our Comfort is, tho' both offend,
We to our Faults can quickly put AN END.
Tranſgreſſor-like, I've to the Preſs been hurl'd,
From thence ſent forth to a Cenſorious World,
BOUND *to my good Behaviour; and to pray*
For a kind Paſſage, that all Envy may
Be quiet, and no crack-brain'd Sceptick grudge;
Let Art examine, then let Candor judge.
Let what's well done (Reader) oblige your View,
And let good Nature pardon Errors too;
We err by Cuſtom from old Adam's *Act,*
Still Heirs unto that meritorious Fact:
Then let each gen'rous Soul afford this kindneſs,
Correct our Faults, for theſe admit no FINIS.

POSTSCRIPT.

1. *Multiplication by Logarithms.*

Rule. ADD the Log. of the Numbers together, the Sum is the Log. of the Product.

Examp. Multiply 14 by 11.

Logarithm of 14 is ——— 1.146128 } Add.
Logarithm of 11 is ——— 1.041393 }
Logarithm of 154 the Product is 2.187521

2. *Division by Logarithms.*

Rule. Subtract the Logar. of the Divisor from the Logar. of the Dividend, the Remainder is the Logar. of the Quotient.

Ex. Divide 125 by 5. { Log. of 125 —— 2.096910 } Subt.
{ Log. of 5. —— 0.698970 }
Log. of the Quote, 25 —— 1.397940

3. *Rule of Three, or Proportion by Logarithms.*

Rule. Add the Logs. of the 2d. and 3d. Numbers together, and from that Sum subtract the Log. of the first Numb. the Remaind. is the Log. of the 4th. Nr. required.

Ex. If a Ship sails 79 Miles in 24 Hours, how long will she be sailing 129 Miles? Ans. 39^h.

Log. { 79^m —— 1.897627
{ 24^h —— 1.380211
{ 129^m — 2.110589
——————
3.490800
——————
Log. 39^h 1.593173
——————

N. B. This Rule of the Logs. holds good in all the Proportions made in *Navigation*, *Astronomy*, &c.

4. *Square Root extracted by Logarithms.*

Rule $\frac{1}{2}$ the Log. of the Square Number is the Log. of its Square Root.

Examp. What's the Square Root of 121 Miles?

Log of 121^m ——— ——— 2.082787
Log of 11. Square Root $\frac{1}{2}$ = 1.041392

5. *Cube Root extracted by Logarithms.*

Rule. $\frac{1}{3}$ of the Log. of the Cube Numb. given, is the Log. of the Cube Root requir'd.

Ex. What is the Cube Root of 125^m?

Log.—125^m. 2.026910 }
Log.—5. $\frac{1}{3}$ = 0.698979 } the Cube Root requir'd.

Soli DEO Gloria.

No. 1. A

TABLE

OF THE

Dominical Letters, Cycle of the Sun, Prime, Epact, Moveable Feasts, and Eclipses for 16 Years.

Years.	Domin. Letter.	Sun's Cycle.	Prime.	Epact.	Shrove Sunday.	Easter Sunday.	Whit-Sunday.
1724	ED	25	15	15	Feb. 16	Apr. 5	May 24
1725	C	26	16	26	7	Mar. 28	16
1726	B	27	17	7	20	Apr. 10	29
1727	A	28	18	18	12	2	2
1728	GF	1	19	29	Mar. 3	21	June 9
1729	E	2	1	11	Feb. 16	6	May 25
1730	D	3	2	22	8	Mar. 29	17
1731	C	4	3	3	28	Apr. 18	June 6
1732	BA	5	4	14	20	9	May 28
1733	G	6	5	25	7	Mar. 25	13
1734	F	7	6	6	24	Apr. 14	June 2
1735	E	8	7	17	16	6	May 25
1736	DC	9	8	28	Mar. 7	25	June 13
1737	B	10	9	9	Feb. 20	10	May 29
1738	A	11	10	20	12	2	21
1739	G	12	11	1	Mar. 4	22	June 10

ECLIPSES of the Sun and Moon for 16 *Years.*

Anno 1724.

1. ☽ Eclipſed *April* 27. Inviſible.
2. ☉ Eclipſ. *May* 11. Viſible, 11 Digits.
3. ☽ Eclipſ. 21. Viſible, 8 Digits.
4. ☉ Eclipſ. *Novemb.* 4. Inviſible.

Anno 1725.

1. ☉	Ecl.	*Apr.* 2.	Inviſ.
2. ☉		*May* 1.	
3. ☽		Oct. 21.	Viſib. and Total 21 Dig.

Anno 1726.

1. ☉	Ecl.	*Mar.* 22.	Inviſible
2. ☽		*Apr.* 5.	Inviſible.
3. ☉		*Sep.* 14.	Viſ. 7 Dig.
4. ☽		*Sep.* 30.	Viſ. 6 Dig.

Anno 1727.

1. ☉	Ecl.	*Mar.* 11.	Inviſib.
2. ☉		*Sept.* 4.	Viſ. 3 Dig.

Anno 1728.

1. ☽ Eclipſ. Viſible 10 Digits.
2. ☽ Eclipſ. *Aug.* 8. Inviſible.
3. ☉ Eclipſ. *Aug.* 23. Inviſible.
4. ☉ Eclipſ. *Feb.* 28. Inviſible.

Anno 1729.

1. ☽ *Febr.* 24. Inviſible.
2. ☉ *March* 10. Inviſible.
3. ☽ Eclipſed *July* 28. Viſible and Total.

Anno 1730.

1. ☽ Eclip. *Jan.* 7. Inviſible.
2. ☉ Eclipſ. *Jan.* 22. Viſible, 5 Digits.
3. ☉ *July* 3. Inviſible.
4. ☽ *July* 18. Inviſible.

Anno 1731.

1. ☽ Eclipſed *June* 8. Viſible, 3 Digits.
2. ☉ Eclipſ. *June* 23. Inviſible.
3. ☉ Eclipſ. *Decemb.* 2. Inviſible.
4. ☉ Eclipſ. *Decemb.* 17. Inviſible.

Anno 1732.

1. ☉ Eclipſ. *May* 28. Inviſible.
2. ☉ Eclipſ. *June* 11. Inviſible
3. ☉ Eclipſ. *Novemb.* 8. Inviſible.
4. ☽ Eclipſ. *Novemb.* 20. Viſible and Total.
5. ☉ Eclipſ. *Decemb.* 6. Inviſible.

ECLIPSES of the Sun and Moon for 16 Years.

Anno 1733.

1. ☾ Eclipſed *May* 2, Viſible 10 Digits.
2. ☽ Eclipſed *May* 17, Viſible and Total.
3. ☉ Eclipſed *Octob.* 26, Inviſible.
4. ☽ Eclipſed *Novemb.* 10, Inviſible.

Anno 1734.

1. ☾ Ecclipſ. *April* 22.
2. ☉ Eclipſ. *October* 15, both Central, but Inviſible.

Anno 1735.

1. ☽ Eclipſ. *Mar.* 27, Inviſible.
2. ☉ Eclipſ. *Apr.* 11, Inviſible
3. ☽ Eclipſ. *Septemb.* 20, Viſible 7 Digits.

Anno 1736.

1. ☾ Eclipſ. *Mar.* 1, Inviſible.
2. ☽ Eclipſ. *Mar.* 15, Viſible and Total;
3. ☉ Eclipſ. *Mar.* 30, Inviſib.
4. ☉ Eclipſ. *Aug.* 25, Inviſible
5. ☽ Eclipſ. *Septemb.* 8, Viſible and Total.
6. ☉ Eclipſ. *Sept.* 23, Inviſible.

Anno 1737.

1. ☾ Eclipſ. *Febr.* 28, Viſible 11 Digits.
2. ☽ Eclipſ. *March* 5, Inviſible.
3. ☉ Eclipſ. *Auguſt* 14, Inviſible.
4. ☽ Eclipſ. *Aug.* 28, Viſible 6 Digits.

Anno 1738.

1. ☉ Eclipſ. *February* 7, Inviſible.
2. ☉ Eclipſ. *Auguſt* 4, Viſible 4 Digits.

Anno 1639.

1. ☽ Eclipſ. *Jan.* 13, Viſible 8 Digits.
2. ☉ Eclipſ. *January* 27, Inviſible.
3. ☽ Eclipſ. *July* 9, Inviſible.
4. ☉ Eclipſ. *July* 24, Viſible 7 Digits.

No. 2. A Table of the Moon's Shining, Distance from the Sun and her Motion for every Day and Hour of her Age.

☽ Age	☽ shine H.	M	☽ dist. ☌ ☉ S.	D.	☽ Mot. S. D. M.	☽ H. Age	Mot. D. M.	No. ☉	Sign. ♈
0	12	0	0 ☌	0	0. 0. 0	1	0.32	1	♉
1	12	48	0	12	0.13.11	2	1. 6		
2	1	36	0	24	6.26.21	3	1.39	2	♊
3	2	24	1	6	1. 9.32	4	2.12		
4	3	12	1	18	1.22.42	5	2.45	3	♋
5	4	0	2 ✱	0	2. 5.53	6	3.18		
6	4	48	2	12	2.19. 3	7	3.51	4	♌
7	5	36	2	24	3. 2.14	8	4.24		
8	6	24	3	6	3.15.25	9	4.56	5	♍
9	7	12	3 □	18	3.28.35	10	5.29		
10	8	0	4	0	4.11.46	11	6. 2	6	♎
11	8	48	4	12	4.24.56	12	6.35		
12	9	36	4	24	5. 8. 7	13	7. 8	7	♏
13	10	24	5	6	5.21.18	14	7.41	8	♐
14	11	12	5	18	6. 4.28	15	8.14		
15	12 ✱	0	6	0	6.17.39	16	8.47	9	♑
16	12	48	6	12	7. 0.49	17	9.20		
17	1	36	6	24	7.14. 0	18	9.53	10	♒
18	2	24	7	6	7.27.11	19	10.26		
19	3	12	7	18	8.10.22	20	10.59	11	♓
20	4	0	8	0	8.23.32	21	11.32		
21	4	48	8	12	9.19.53	22	12. 5		
22	5	36	8	24	9. 3. 3	23	12.38		
23	6	24	9 □	6	10.16.14	24	13.11		
24	7	12	9	18	10.29.25				
25	8	0	10	0	11.12.35				
26	8	48	10	12	11.29.46				
27	9	36	10	24	0. 8.56				
28	10	24	11	6	0.22.27				
29	11	12	11	18					
30	12	0	12 ☌	0					

Afternoon

The Morning

No 3.

N°. 3. *A* TABLE *shewing the Moon's Changing for 8 Years.*

Years.	*Jan.*	*Febr.*	*Mar.*	*April.*	*May.*	*June.*	*July.*	*August.*	*Sept.*	*October.*	*Novemb.*	*Decemb.*
	D. H.	D. H.	D. H.	D. H.	D. H.	D. H.	D. H.	D. H.	D. H.	D. H.	D. H.	D. H.
1724	15.4m	13.4 a	14.3m	12.10m	11. 5 a	10. 1m	9. 10m	7. 9 a	6. 11m	6. 3m	4. 11 a	4. 5N
1725	3.11m	2. 3m	3. 4 a	2. 2m	1. 10m 30. 5 a	28.12 a	28. 8m	26.6 a	25. 7m	24.11 a	23. 5 a	23. 0
1726	27.7m	26.12a	22.2 a	21. 2m	20.11m	18. 6 a	17 12 a	16.8m	14. 5m	14. 4m	12. 6 a	12. 0
1727	11.7m	10.1m	11.8 a	10.11m	9. 12 a	18. 9 a	7. 5 a	6. 1m	4. 8m	3. 6 a	2. 5m	1. 5 a 31. 8m
1728	30.2m	28.8 a	29.1 a	28. 5m	27. 7 a	26. 6m	25. 4 a	24.1m	22.10m	21. 7 a	20. 5m	19. 5 a
1729	10.4 a	9.10m	11.3m	9. 8 a	16.10 a	15 *Noon*	15. 2 a	13.2 a	12. 1m	11.11m	9. 10 a	9. 7m
1730	7. 7 a	6. 6m	7. 7 a	6. 9m	5. 11 a	4. 2 a	4. 5m	2. 8 a	1. 10m 30.11 a	30. N.	28.11 a	28.11m
1731	26.9 a	25.7m	26.5 a	25. 4m	24. 4 a	23. 6m	22. 9 a	21.1 a	20. 5m	19. 9 a	18 N.	18. 1m

A TABLE *of the Moon's Southing.*

☽ *Age*	1 / 16	2 / 17	3 / 18	4 / 19	5 / 20	6 / 21	7 / 22	8 / 23	9 / 24	10 / 25	11 / 26	12 / 27	13 / 28	14 / 29	15 / 30	Afternoon. / Morning.
Time.	h. 1	h. 1	h. 1	h. 1	h. 1	h. 1	h. 1	h. 1	h. 1	h. 1	h. 1	h. 1	h. 1	h. 1	h. 1	
☽ *Sou.*	0.48	1.36	2.24	3.12	4. 0	4.48	5.36	6.24	7.12	8. 0	8.48	9 36	10.24	11.12	12.0	

Rules *for the Moon's Rising and Setting.*

RULE 1.

Increase { ☉ rising + ☽ shining = ☽ rising ; ☉ setting + ☽ shining = ☽ setting }

Decrease { ☉ rising − ☽ shining = ☽ rising ; ☉ setting − ☽ shining = ☽ setting }

RULE 2.

☽ New } Rises and sets with the Sun.
Full } Rises at Sun setting, and sets at Sun rising.

☽ Beginning to Increase, riseth a little after Sun rising, and sets a little after Sun setting.

☽ Beginning to Decrease, riseth a little after Sun setting, and setteth a little after Sun rising.

☽ In her first Quarter rises about Noon, and sets about Midnight.

Lastly, ☽ Riseth every day 48 Minutes later as in her Southing.

NOTE, When it's New Moon, the Sun and Moon are both in the same Sign and Degree of the Ecliptick. And then the Sun may be Eclipsed, by the Moon coming between the Sun and our Sight.

At Full Moon she is Opposite to the Sun: And then the Moon may be Eclipsed, by the Earth's Interposition between the Sun and Moon exactly Diametrical.

No. 4. *A* TABLE *of the Angles which every Point of the Compass maketh with the Meridian: Also the Time answering each Point.*

North.	South.	North.	South.	Point	D. M.	H. M. ".
Note, each Point is ¼ of an Hour, to be reckoned North-Easterly to the South, and South-Westerly to the North Point.				¼	2. 49	0. 33. 40
				½	5. 37	0. 25. 40
				¾	8. 26	0. 33. 44
N. by E.	S. by E.	N. by W.	S. by W.	1	11. 15	0. 45 0
Divide 360°. by 32. the Points, the Quote is 11°. ¼. each Point of the Compass.				1 ¼	14. 04	
				1 ½	16. 52	
				1 ¾	19. 41	
N. N. E.	S. S. E.	N. N. W.	S. S. W.	2	22. 30	1. 30
				2 ¼	25. 19	
				2 ½	28. 07	
				2 ¾	30. 56	
N. E. b. N.	S. E. b. S.	N. W. b. N.	S. W. b. S.	3	33. 45	2. 15
				3 ¼	36. 34	
				3 ½	39. 22	
				3 ¾	42. 11	
N. East.	S. East.	N. West.	S. West.	4	45. 0	3. 0
				4 ¼	47. 49	
				4 ½	50. 38	
				4 ¾	53. 26	
N. E. b. E.	S. E. b. E.	N. W. b. W.	S. W. b. W.	5	56. 15	3. 45
				5 ¼	59. 04	
				5 ½	61. 53	
				5 ¾	64. 41	
E N. E.	E. S. E.	W. N. W.	W. S. W.	6	67. 30	4. 30
Divide 11°. 15′ by 15°. (= 1 hour) the Quote is 0h. 45 m. in Time for each Point.				6 ¼	70. 19	
				6 ½	73. 08	
				6 ¾	75. 56	
E. b. N.	E. b. S.	W. b. N.	W. b. S.	7	78. 45	5. 15
				7 ¼	81. 34	
				7 ½	84. 23	
				7 ¾	87. 11	
East.	East.	West.	West.	8	90. 00	6. 0

N°. 5.

No. 5. A General TIDE-TABLE.

Age ☾ D.	N.E.b.N. S.W.b.S	E. b. S. W. b. N.	S. S. E. N. N. W.	N. and S.	E. and W.	E. b. N. W. b. S.	N.E.b.E. S.W.b.W.	E.S.E. W.N.W.
	London. Yarmouth. Hartlo. Whitby. Dundee.	Briſtol. Lanion. Lime. Sidmouth. S. Davids.	Dover R. Tarmouth. Harwich. Orwell. Callis R.	Queenb. Southam. Portſm. Dunkirk. Oſtend.	Plymouth. Weymouth. Salcomb. Hull Liv. Boſton.	Newcaſt. Folmouth. Dartm. Torbay. Foy.	Berwick. Flamboro. Scarbor. Bridlington Bay.	Bridgwa. Exeter. Pool. Portland. Liming.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
1	3. 0	7. 33	11.18	12.48	6. 48	6. 3	4. 33	8. 18
2	3. 48	8. 21	12. 6	1. 36	7. 51	6. 51	5. 21	9. 6
3	4. 36	9. 9	12.54	2. 24	8. 39	7. 39	6. 9	9. 54
4	5. 24	9. 57	1. 42	3. 12	9. 27	8. 27	6. 57	10.42
5	6. 12	10.45	2. 30	4. 0	10.15	9. 15	7. 42	11.30
6	7. 0	11.33	3. 18	4. 48	11. 3	10. 3	8. 33	12.18
7	7. 48	12.21	4. 6	5. 36	11.51	10.51	9. 21	1. 6
8	8. 36	1. 9	4. 54	6. 24	12.39	11.39	10. 9	1. 54
9	9. 24	1. 57	5. 42	7. 12	1. 27	12.27	10.57	2. 42
10	10.12	2. 45	6. 30	8. 0	2. 15	1. 15	11.42	3. 30
11	11. 0	3. 33	7. 18	8. 48	3. 3	2. 3	12.33	4. 18
12	11.48	4. 21	8. 6	9. 36	3. 51	2. 51	1. 21	5. 6
13	12.36	5. 9	8. 54	10.24	4. 39	3. 39	2. 9	5. 54
14	1. 24	5. 57	9. 42	11.12	5. 27	4. 27	2. 57	6. 42
15 ○	2. 12	6. 45	10.30	12. 0	6. 0	5. 15	3. 42	7. 30
16	3. 0	7. 33	11.18	0. 48	6. 48	6. 3	4. 33	8. 18
17	3. 48	8. 21	12. 6	1. 36	7. 51	6. 51	5. 21	9. 6
18	4. 36	9. 9	12.54	2. 24	8. 39	7. 39	6. 9	9. 54
19	5. 24	9. 57	1. 42	3. 12	9. 27	8. 27	6. 57	10.42
20	6. 12	10.45	2. 30	4. 0	10.15	9. 15	7. 42	11.30
21	7. 0	11.33	3. 18	4. 48	11. 3	10. 3	8. 33	12.18
22	7. 48	12.21	4. 6	5. 36	11.51	10.51	9. 21	1. 6
23	8. 36	1. 9	4. 54	6. 24	12.39	11.39	10. 9	1. 54
24	9. 24	1. 57	5. 42	7. 12	1. 27	12.27	10.57	2. 42
25	10.12	2. 45	6. 30	8. 0	2. 15	1. 15	11.42	3. 30
26	11. 0	3. 33	7. 18	8. 48	3. 3	2. 3	12.33	4. 18
27	11.48	4. 21	8. 6	9. 36	3. 51	2. 51	1. 21	5. 6
28	12.36	5. 9	8. 54	10.24	4. 39	3. 39	2. 9	5. 54
29	1. 24	5. 57	9. 42	11.12	5. 27	4. 27	2. 57	6. 42
30 ●	12. 2	6. 45	10.30	12. 0	6. 0	5. 15	3. 42	7. 30
	H. I.	H. I.	H. I.	H. I.	H. I.	H. I.	H. I.	H. I.
Age ☽	Amſterd. Rx. Hood's Bay. Denby. Lisbon.	St. Nicholas. Foulneſs. At the Start.	Solebay. Leyſtiff R. Gravſend. Margate-Road.	Beachy. Kent. Kn. The Nore. Iſle of Wight.	Antwerp. Hamborough. Off Silly. Off Bourd. Humber.	S. Malo's. Milford. Mounts-Bay. Lizard. Spurn.	In R. Bourd. Rochel. Uſhant within. at Silly.	Texel R. The Foy. Hague. Dublin. Cape Clear.
	N.E.b.N. S.W.b.S.	E. b. S. W. b. N.	S. S. E. N. N. W.	N. and S.	E. and W.	E. b. N. W. b. S.	N.E.b.E. S.W.b.W.	S.S.E. W.N.W.

A

TABLE

OF

Logarithm-Numbers,

From 1. to 1020.

N.	Logarith.	N.	Logrrith.	N.	Logarith.
1	0.000000	35	1.544068	69	1.838849
2	0.301030	36	1.556303	70	1.845098
3	0.477121	37	1.568202	71	1.851258
4	0.602060	38	1.579783	72	1.857332
5	0.698970	39	1.591064	73	1.863323
6	0.778151	40	1.602060	74	1.869232
7	0.845098	41	1.612784	75	1.875061
8	0.903090	42	1.623249	76	1.880813
9	0.954242	43	1.633468	77	1.886491
10	1.000000	44	1.643452	78	1.892094
11	1.041393	45	1.653212	79	1.897627
12	1.079181	46	1.662758	80	1.903090
13	1.113943	47	1.672098	81	1.908485
14	1.146128	48	1.681241	82	1.913814
15	1.176091	49	1.690196	83	1.919078
16	1.204120	50	1.698970	84	1.924279
17	1.230449	51	1.707570	85	1.929419
18	1.255272	52	1.716003	86	1.934498
19	1.278753	53	1.724276	87	1.939519
20	1.301230	54	1.732394	88	1.944482
21	1.322219	55	1.740362	89	1.949390
22	1.342422	56	1.748188	90	1.954242
23	1.361728	57	1.755875	91	1.959041
24	1.380211	58	1.763428	92	1.963788
25	1.397940	59	1.770852	93	1.968483
26	1.414973	60	1.778151	94	1.973128
27	1.431364	61	1.785330	95	1.977723
28	1.447121	62	1.792391	96	1.982271
29	1.462398	63	1.799340	97	1.986772
30	1.477121	64	1.806180	98	1.991226
31	1.491361	65	1.812913	99	1.995635
32	1.505150	66	1.819544	100	2.000000
33	1.518514	67	1.826075	101	2.004321
34	1.531479	68	1.832509	102	2.008600

N.	Logarith.
103	2.012837
104	2.017033
105	2.021189
106	2.025306
107	2.029384
108	2.033424
109	2.037426
110	2.041393
111	2.045323
112	2.049218
113	2.053078
114	2.056905
115	2.060698
116	2.064458
117	2.068186
118	2.071882
119	2.075547
120	2.079181
121	2.082785
122	2.086359
123	2.089905
124	2.093422
125	2.096910
126	2.100371
127	2.103804
128	2.107209
129	2.110589
130	2.113943
131	2.117271
132	2.120574
133	2.123852
134	2.127105
135	2.130334
136	2.133539
137	2.136721
138	2.139879
139	2.143015
140	2.146128
141	2.149219
142	2.152288
143	2.155336
144	2.158362
145	2.161368
146	2.164353
147	2.167317
148	2.170262
149	2.173186
150	2.176091
151	2.178977
152	2.181844
153	2.184691
154	2.187521
155	2.190332
156	2.193125
157	2.195899
158	2.198657
159	2.201397
160	2.204120
161	2.206826
162	2.209515
163	2.212187
164	2.214844
165	2.217484
166	2.220108
167	2.222716
168	2.225309
169	2.227887
170	2.230449
171	2.232996
172	2.235528
173	2.238046
174	2.240549
175	2.243038
176	2.245513
177	2.247973
178	2.250420
179	2.252853
180	2.255273
181	2.257679
182	2.260071
183	2.262451
184	2.264818
185	2.267172
186	2.269513
187	2.271842
188	2.274158
189	2.276462
190	2.278754
191	2.281033
192	2.283301
193	2.285557
194	2.287802
195	2.290035
196	2.292256
197	2.294466
198	2.296665
199	2.298853
200	2.301029
201	2.303196
202	2.305351
203	2.307496
204	2.309630

N.	Logarith.	N.	Logarith.	N.	Logarith.
205	2.311754	239	2.378398	273	2.436163
206	2.313867	240	2.380211	274	2.437751
207	2.315970	241	2.382017	275	2.439333
208	2.318063	242	2.383815	276	2.440909
209	2.320146	243	2.385606	277	2.442479
210	2.322219	244	2.387389	278	2.444045
211	2.324282	245	2.389166	279	2.445604
212	2.326336	246	2.390935	280	2.447158
213	2.328379	247	2.392697	281	2.448706
214	2.330414	248	2.394452	282	2.450249
215	2.332438	249	2.326199	283	2.451786
216	2.334454	250	2.397940	284	2.453318
217	2.336459	251	2.399674	285	2.454845
218	2.338456	252	2.401401	286	2.456366
219	2.340444	253	2.403121	287	2.457889
220	2.342422	254	2.404834	288	2.459362
221	2.344392	255	2.406540	289	2.460898
222	2.346353	256	2.408239	290	2.462398
223	2.348305	257	2.409933	291	2.463893
224	2.350248	258	2.411619	292	2.465383
225	2.352183	259	2.413299	293	2.466868
226	2.354108	260	2.414973	294	2.468347
227	2.356026	261	2.416641	295	2.469822
228	2.357935	262	2.418301	296	2.471292
229	2.359835	263	2.419956	297	2.472756
230	2.361728	264	2.421604	298	2.474216
231	2.363612	265	2.423246	299	2.475671
232	2.365488	266	2.424882	300	2.477121
233	2.367356	267	2.426511	301	2.478566
234	2.369216	268	2.428135	302	2.480007
235	2.371068	269	2.429752	303	2.481443
236	2.372912	270	2.421364	304	2.482874
237	2.374748	271	2.432969	305	2.484299
238	2.376577	272	2.434569	306	2.485721

N.	Logarith.	N.	Logarith.	N.	Logarith.
307	2.487138	341	2.532754	375	2.574031
308	2.488551	342	2.534026	376	2.575188
309	2.489958	343	2.535294	377	2.576341
310	2.491362	344	2.536558	378	2.577492
311	2.492760	345	2.537819	379	2.578639
312	2.494155	346	2.539076	380	2.579784
313	2.495544	347	2.540329	381	2.580925
314	2.496929	348	2.541579	382	2.582063
315	2.498311	349	2.542825	383	2.583199
316	2.499687	350	2.544008	384	2.584331
317	2.501059	351	2.545307	385	2.585461
318	2.502427	352	2.546543	386	2.586587
319	2.503791	353	2.547775	387	2.587711
320	2.505149	354	2.549003	388	2.588832
321	2.506505	355	2.550228	389	2.589949
322	2.507856	356	2.551449	390	2.591065
323	2.509203	357	2.552668	391	2.592177
324	2.510545	358	2.553883	392	2.593286
325	2.511883	359	2.555094	393	2.594393
326	2.513218	360	2.556303	394	2.595496
327	2.514548	361	2.557507	395	2.596597
328	2.515874	362	2.558709	396	2.597695
329	2.517196	363	2.559907	397	2.498790
330	2.518514	364	2.561101	398	2.599883
331	2.519828	365	2.562293	399	2.600973
332	2.521138	366	2.563481	400	2.602059
333	2.522444	367	2.564666	401	2.603144
334	2.523746	368	2.565848	402	2.604226
335	2.525045	369	2.567026	403	2.605305
336	2.526339	370	2.568202	404	2.606381
337	2.527629	371	2.569374	405	2.607455
338	2.528916	372	2.570543	406	2.608526
339	2.530199	373	2.571709	407	2.609594
340	2.531479	374	2.572872	408	2.610660

N.	Logarith.
409	2.611723
410	2.612784
411	2.613842
412	2.614897
413	2.615950
414	2.617000
415	2.618048
416	2.619093
417	2.620136
418	2.621176
419	2.622214
420	2.623249
421	2.624282
422	2.625312
423	2.626340
424	2.627366
425	2.628389
426	2.629409
427	2.630428
428	2.631444
429	2.632457
430	2.633468
431	2.634477
432	2.635484
433	2.636488
434	2.637489
435	2.638489
436	2.639486
437	2.640481
438	2.641475
439	2.642465
440	2.643453
441	2.644439
442	2.645422
443	2.646404
444	2.647383
445	2.648360
446	2.649335
447	2.650308
448	2.651278
449	2.652246
450	2.653213
451	2.654177
452	2.655138
453	2.656098
454	2.657056
455	2.658011
456	2.658965
457	2.659916
458	2.660865
459	2.661813
460	2.662758
461	2.663642
462	2.664643
463	2.665581
464	2.666518
465	2.667453
466	2.668386
467	2.669317
468	2.670246
469	2.671173
470	2.672098
471	2.673021
472	2.673942
473	2.674861
474	2.675778
475	2.676694
476	2.677607
477	2.678518
478	2.679428
479	2.680336
480	2.681241
481	2.682145
482	2.683047
483	2.683947
484	2.684845
485	2.685742
486	2.686636
487	2.687529
488	2.688419
489	2.689309
490	2.690196
491	2.691081
492	2.691965
493	2.692847
494	2.693727
495	2.694605
496	2.695482
497	2.696356
498	2.697229
499	2.698101
500	2.698970
501	2.699838
502	2.700704
503	2.701568
504	2.702430
505	2.703291
506	2.704151
507	2.705008
508	2.705863
509	2.706718
510	2.707570

N.	Logarith.	N.	Logarith.	N.	Logarith.
511	2.708421	545	2.736397	579	2.762679
512	2.709269	546	2.737192	580	2.763428
513	2.710117	547	2.737987	581	2.764176
514	2.710963	548	2.738781	582	2.764923
515	2.711807	549	2.739572	583	2.765669
516	2.712649	550	2.740363	584	2.766413
517	2.713491	551	2.741152	585	2.767156
518	2.714329	552	2.741939	586	2.767898
519	2.715167	553	2.742725	587	2.768638
520	2.716003	554	2.743509	588	2.769377
521	2.716838	555	2.744293	589	2.770115
522	2.717671	556	2.745075	590	2.770852
523	2.718502	557	2.745855	591	2.771587
524	2.719331	558	2.746634	592	2.772322
525	2.720159	559	2.747412	593	2.773055
526	2.720986	560	2.748188	594	2.773786
527	2.721811	561	2.748963	595	2.774517
528	2.722634	562	2.749736	596	2.775246
529	2.723456	563	2.750508	597	2.775974
530	2.724276	564	2.751279	598	2.776701
531	2.725095	565	2.752048	599	2.777427
532	2.725912	566	2.752816	600	2.778151
533	2.726727	567	2.753583	601	2.778874
534	2.727541	568	2.754348	602	2.779596
535	2.728354	569	2.755112	603	2.780317
536	2.729165	570	2.755875	604	2.781037
537	2.729974	571	2.756636	605	2.781755
538	2.730782	572	2.757396	606	2.782473
539	2.731589	573	2.758155	607	2.783189
540	2.732394	574	2.758912	608	2.783904
541	2.733197	575	2.759668	609	2.784617
542	2.733999	576	2.760422	610	2.785329
543	2.734799	577	2.761176	611	2.786041
544	2.735599	578	2.761928	612	2.786751

N.	Logarith.	N.	Logarith.	N.	Logarith.
613	2.787460	647	2.810904	681	2.833147
614	2.788164	648	2.811575	682	2.833784
615	2.788875	649	2.812245	683	2.834421
616	2.789581	650	2.812913	684	2.835056
617	2.790285	651	2.813581	685	2.835691
618	2.790988	652	2.814248	686	2.836324
619	2.791691	653	2.814913	687	2.836957
620	2.792392	654	2 815578	688	2.837588
621	2.793092	655	2.816241	689	2.838219
622	2.793791	656	2.816904	690	2.838849
623	2.794488	657	2.817565	691	2.839478
624	2.795185	658	2.818226	692	2.840106
625	2.795880	659	2.818885	693	2.840733
626	2.796574	660	2.819543	694	2.841359
627	2.797268	661	2.820201	695	2.841985
628	2.797959	662	2.820858	696	2.842609
629	2.798651	663	2.821514	697	2.843233
630	2.799341	664	2.822168	698	2.843855
631	2.800029	665	2.822822	699	2.844477
632	2.800717	666	2.823474	700	2.845098
633	2.801404	667	2.824126	701	2.845718
634	2.802089	668	2.824776	702	2.846337
635	2.802774	669	2.825426	703	2.846955
636	2.803457	670	2.826075	704	2.847573
637	2.804139	671	2.826723	705	2.848189
638	2.804821	672	2.827369	706	2.848805
639	2.805501	673	2.828015	707	2.849419
640	2.806179	674	2.828659	708	2.850033
641	2.806858	675	2.829304	709	2.850646
542	2 807535	676	2.829947	710	2.851258
643	2.808211	677	2.830589	711	2.851869
644	2.808886	678	2.831229	712	2.852479
645	2.809559	679	2.832869	713	2.853089
646	2.810904	680	2.832509	714	2.853698

N.	Logarith.	N.	Logarith.	N.	Logarith.
715	2.854306	749	2.874482	783	2.893762
716	2.854913	750	2.875061	784	2.894316
717	2.855519	751	2.875639	785	2.894869
718	2.856124	752	2.876218	786	2.895423
719	2.856729	753	2.876795	787	2.895975
720	2.857332	754	2.877371	788	2.896526
721	2.857935	755	2.877947	789	2.897077
722	2.858537	756	2.878522	790	2.897627
723	2.859138	757	2.879096	791	2.898176
724	2.859739	758	2.879669	792	2.898725
725	2.860338	759	2.880242	793	2.899273
726	2.860937	760	2.880814	794	2.899821
727	2.861534	761	2.881385	795	2.900367
728	2.862131	762	2.881955	796	2.900913
729	2.862728	763	2.882525	797	2.901458
730	2.863323	764	2.883093	798	2.902003
731	2.863917	765	2.883661	799	2.902547
732	2.864511	766	2.884229	800	2.903090
733	2.865104	767	2.884795	801	2.903633
734	2.865696	768	2.885361	802	2.904174
735	2.866287	769	2.885926	803	2.904716
736	2.866878	770	2.886491	804	2.905256
737	2.867467	771	2.887054	805	2.905796
738	2.868056	772	2.887617	806	2.906335
739	2.868643	773	2.888179	807	2.906874
740	2.869232	774	2.888741	808	2.907411
741	2.869818	775	2.889302	809	2.907949
742	2.870404	776	2.889862	810	2.908485
743	2.870989	777	2.890421	811	2.909026
744	2.871573	778	2.890979	812	2.909556
745	2.872156	779	2.891537	813	2.910090
746	2.872739	780	2.892095	814	2.910624
747	2.873321	781	2.892651	815	2.911158
748	2.873902	782	2.893207	816	2.911690

N.	Logarith	N.	Logarith.	N.	Logarith.
817	2.912222	851	2.929929	885	2.946943
818	2.912753	852	2.930439	886	2.947434
819	2.913284	853	2.930949	887	2.947924
820	2.913814	854	2.931458	888	2.948413
821	2.914343	855	2.931966	889	2.948902
822	2.914872	856	2.932474	890	2.949390
823	2.915399	857	2.932981	891	2.940878
824	2.915927	858	2.933487	892	2.950365
825	2.916454	859	2.933993	893	2.950851
826	2.916980	860	2.934498	894	2.951338
827	2.917506	861	2.935003	895	2.951823
828	2.918555	862	2.935507	896	2.952308
829	2.918030	863	2.936011	897	2.952792
830	2.919078	864	2.936514	898	2.953276
831	2.919678	865	2.937016	899	2.953759
832	2.920123	866	2.937518	900	2.954243
833	2.920645	867	2.938019	901	2.954725
834	2.921166	868	2.938519	902	2.955207
835	2.921686	869	2.939019	903	2.955688
836	2.922206	870	2.939519	904	2.956168
837	2.922725	871	2.940018	905	2.956649
838	2.923244	872	2.940516	906	2.957128
839	2.923762	873	2.941014	907	2.957607
840	2.924276	874	2.941511	908	2.958086
841	2.924717	875	2.942004	909	2.958564
842	2.925312	876	2.942508	910	2.959041
843	2.925828	877	2.942999	911	2.959518
844	2.926342	878	2.943495	912	2.959995
845	2.926857	879	2.943989	913	2.960471
846	2.927370	880	2.944483	914	2.960946
847	2.927883	881	2.944976	915	2.961401
848	2.928396	882	2.945468	916	2.961895
849	2.928908	883	2.945961	917	2.962369
850	2.929419	884	2.946452	918	2.962840

N.	Logarith.	N.	Logarith.	N.	Logarith.
919	2.963315	953	2.979093	987	2.994317
920	2.963788	954	2.979548	988	2.994756
921	2.964259	955	2.980003	989	2.995196
922	2.964731	956	2.980458	990	2.995635
923	2.965202	957	2.980912	991	2.996074
924	2.965672	958	2.981365	992	2.996512
925	2.966142	959	2.981819	993	2.996949
926	2.966611	960	2.982271	994	2.997386
927	2.967079	961	2.982723	995	2.997823
928	2.967548	962	2.983175	996	2.998259
929	2.968016	963	2.983626	997	2.998695
930	2.968483	964	2.984077	998	2.999133
931	2.968949	965	2.984527	999	2.999565
932	2.969416	966	2.984977	1000	3.000000
933	2.969847	967	2.985426	1001	3.000434
934	2.970347	968	2.985875	1002	3.000868
935	2.970812	969	2.986324	1003	3.001301
936	2.971276	970	2.986772	1004	3.001734
937	2.971739	971	2.987219	1005	3.002166
938	2.972203	972	2.987666	1006	3.002598
939	2.972666	973	2.988113	1007	3.003029
940	2.973128	974	2.988559	1008	3.003460
941	2.973589	975	2.989005	1009	3.003891
942	2.974050	976	2.989449	1010	3.004321
943	2.974512	977	2.989895	1011	3.004751
944	2.974972	978	2.990339	1012	3.005180
945	2.975432	979	2.990783	1013	3.005609
946	2.975891	980	2.991226	1014	3.006038
947	2.976349	981	2.991669	1015	3.006466
948	2.976808	982	2.992111	1016	3.006894
949	2.977266	983	2.992554	1017	3.007321
950	2.977724	984	2.992995	1018	3.007748
951	2.978181	985	2.993436	1019	3.008174
952	2.978637	986	2.993877	1020	3.008600

D.	N.Sine	N.Tang.	Log. Sine.	Log.Tang.	Log. Secant.
1	1745	1746	8.241855	8.241921	10.000068
2	3490	3492	8.542819	8.543083	10.000269
3	5234	5241	8.718800	8.719395	10.000602
4	6976	6993	8.843584	8.844643	10.001068
5	8716	8749	8.940296	8.941951	10.001656
6	10453	10510	9.019234	9.021620	10.002386
7	12187	12278	9.085894	9.089143	10.003249
8	13917	14054	9.143555	9.147802	10.004247
9	15643	15838	9.194332	9.199712	10.005380
10	17365	17633	9.239670	9.246318	10.006648
11	19081	19438	9.280598	9.288652	10.008053
12	20791	21256	9.317878	9.327474	10.009596
13	22495	23087	9.352088	9.363364	10.011276
14	24192	24933	9.383675	9.396771	10.013096
15	25882	26795	9.412996	9 428052	10.015056
16	27564	28675	9.440338	9.457496	10.017158
17	29237	30573	9.465935	9.485339	10 019404
18	30902	32492	9.489982	9.511796	10.021794
19	32557	34433	9.512641	9 536971	10 024330
20	34202	36397	9.534051	9 561065	10.027014
21	35837	38386	9.554329	9.584177	10.029848
22	37461	40403	9.573575	9.606406	10.032834
23	39073	42447	9.591878	9.627851	10.035974
24	40674	44523	9.609313	9.648583	10.039270
25	42262	46631	9.625948	9.668672	10.042724
26	43837	48773	9 641842	9.688181	10.046340
27	45399	50953	9.657016	9 707165	10.050119
28	46947	53171	9.671609	9.725674	10.054065
29	48481	55431	9 685571	9 743752	10.058181
30	50000	57735	9.698970	9 761439	10.062469

D.	N. Sine	N. Tang.	Log. Sine	Log. Tang.	Log. Secant
31	51504	60086	9.711839	9.778773	10.066934
32	52992	62487	9.724209	9.795789	10.071579
33	54464	64941	9.736108	9.812517	10.076409
34	55919	67451	9.747561	9.828987	10.081426
35	57358	70021	9.758591	9.845226	10.086635
36	58779	72654	9.769218	9.861261	10.092042
37	60181	75355	9.779463	9.877114	10.097651
38	61566	78129	9.789342	9.892809	10.103468
39	62932	80978	9.798871	9.908369	10.109497
40	64279	83910	9.808067	9.923813	10.115746
41	65606	86929	9.816942	9.939163	10.122220
42	66913	90040	9.825510	9.954437	10.128926
43	68200	93252	9.833783	9.969655	10.135872
44	69466	96569	9.841771	9.984837	10.143066
45	70711	100000	9.849485	10.000000	10.150515
46	71934	103553	9.856934	10.015162	10.158229
47	73135	107237	9.864127	10.030344	10.166217
48	74314	111061	9.871073	10.045562	10.174489
49	75471	115037	9.877779	10.060836	10.183057
50	76604	119175	9.884254	10.076186	10.191932
51	77715	123490	9.890502	10.091630	10.201128
52	78801	127994	9.896532	10.107190	10.210658
53	79864	132704	9.902348	10.122885	10.220537
54	80902	137638	9.907957	10.138739	10.230781
55	81915	142815	9.913364	10.154773	10.241409
56	82904	148256	9.918574	10.171012	10.252438
57	83867	153986	9.923591	10.187482	10.263891
58	84805	160033	9.928420	10.204210	10.275790
59	85717	166428	9.933065	10.221226	10.288161
60	86603	173205	9.937530	10.238560	10.301030

D.	N. Sine	N. Tang.	Log. Sine.	Log. Tang.	Log. Secant.
61	87462	180405	9.941818	10.256248	10.314429
62	88295	188073	9.945934	10.274325	10.328391
63	89101	196261	9.949881	10.292834	10.342953
64	89879	205030	9.953660	10.311818	10.358158
65	90631	214451	9.957275	10 331327	10.374052
66	91355	224604	9.960730	10.351416	10.390687
67	92050	235585	9.964026	10.372148	10.408122
68	92718	247509	9.967166	10.393590	10.426425
69	93358	260509	9.970151	10.415822	10.445671
70	93969	274748	9.972985	10.438934	10.465948
71	94552	290421	9.975670	10.463026	10.487358
72	95106	307768	9.978206	10.488224	10 510018
73	95630	327085	9.980596	10.514661	10.534065
74	96126	348741	9.982841	10.542503	10.559662
75	96593	373205	9.984943	10 571947	10.587004
76	97030	401078	9.986904	10 603228	10.616325
77	97437	433148	9 988723	10.636635	10.647912
78	97815	470463	9 990404	10.672525	10.682121
79	98163	514455	9.991946	10.711347	10.719401
80	98481	567128	9 993351	10.753681	10.760330
81	98769	631375	9.994619	10.800287	10.805668
82	99027	711537	9.995752	10.852197	10.856445
83	99255	814435	9.996750	10.910856	10.914105
84	99452	951436	9.997614	10.978379	10 980765
85	99619	1143005	9.998344	11.058048	11.059704
86	99756	1430067	9.998940	11.155356	11.156415
87	99863	1908114	9 999404	11.280604	11.281200
88	99939	2863625	9.999735	11.456916	11.457181
89	99985	5728996	9.999933	11 758078	11.758145
90	100000	Infinite.	10.000000	Infinite.	Infinite.

P.	N.Sine	N.Tan.	Log. Line.	Log. Tang.	Log. Sec.
1	49	49	8.688863	8.689381	10.000519
2	98	98	8.990660	8.992750	10.002090
3	147	148	9.165454	9.170157	10.004703
I.	195	199	9.290236	9.298662	10.008426
1	243	250	9.385697	9.398919	10.013222
2	290	303	9.463032	9.482167	10.019134
3	337	358	9.527400	9.553548	10.026148
II.	383	414	9.582840	9.617224	10.034385
1	428	473	9.631059	9.674910	10.043852
2	471	534	9.673505	9.728109	10.054604
3	515	599	9.710997	9.777628	10.066631
III.	555	668	9.744739	9.824893	10.080154
1	596	742	9.775070	9.870265	10.095196
2	634	820	9.802435	9.914560	10.111866
3	671	906	9.827049	9.957231	10.130182
IV.	707	1000	9.849485	10.000000	10.150515
1	741	1103	9.869933	10.042769	10.172951
2	773	1218	9.888133	10.085698	10.197564
3	803	1348	9.904804	10.129735	10.224930
V.	831	1496	9.919846	10.175107	10.255261
1	858	1668	9.933369	10.222372	10.289214
2	882	1870	9.945396	10.271891	10.326495
3	904	2188	9.956148	10.325089	10.368941
VI.	924	2414	9.965615	10.382776	11.417160
1	941	2795	9.973852	10.446452	10.472600
2	957	3249	9.980866	10.517833	10.536968
3	970	3991	9.986778	10.601081	10.614303
VII.	981	5112	9.991574	10.701338	10.709764
1	989	6749	9.995278	10.828971	10.833693
2	995	10138	9.997897	11.005955	11.008057
3	999	20205	9.999475	11.308037	11.308562
VIII.	1000	*Infinit*	10.000000	*Infinite.*	*Infinite.*

N.	Squ	N.	Squ.	N.	Squ.	N.	Squ.	N.	Squ.	N.	Squ.
1	1	31	961	61	3721	91	8281	121	14641	151	22801
2	4	32	1024	62	3844	92	8464	122	14884	152	23104
3	9	33	1089	63	3969	93	8649	123	15129	153	23409
4	16	34	1156	64	4096	94	8836	124	15376	154	23716
5	25	35	1225	65	4225	95	9025	125	15625	155	24025
6	36	36	1296	66	4356	96	9216	126	15876	156	24336
7	49	37	1369	67	4489	97	9409	127	16129	157	24649
8	64	38	1444	68	4624	98	9604	128	16384	158	24964
9	81	39	1521	69	4761	99	9801	129	16641	159	25281
10	100	40	1600	70	4900	100	10000	130	16900	160	25600
11	121	41	1681	71	5041	101	10201	131	17161	161	25921
12	144	42	1764	72	5184	102	10404	132	17424	162	26244
13	169	43	1849	73	5329	103	10609	133	17689	163	26569
14	196	44	1936	74	5476	104	10816	134	17956	164	26896
15	225	45	2025	75	5625	105	11025	135	18225	165	27225
16	256	46	2116	76	5776	106	11236	136	18496	166	27556
17	289	47	2209	77	5929	107	11449	137	18769	167	27889
18	324	48	2304	78	6084	108	11664	138	19044	168	28224
19	361	49	2401	79	6241	109	11881	139	19321	169	28561
20	400	50	2500	80	6400	110	12100	140	19600	170	28900
21	441	51	2601	81	6561	111	12321	141	19881	171	29241
22	484	52	2704	82	6724	112	12544	142	20164	172	29584
23	529	53	2809	83	6889	113	12769	143	20449	173	29929
24	576	54	2916	84	7056	114	12996	144	20736	174	30276
25	625	55	3025	85	7225	115	13225	145	21025	175	30625
26	676	56	3136	86	7396	116	13456	146	21316	176	30976
27	729	57	3249	87	7569	117	13689	147	21609	177	31329
28	784	58	3364	88	7744	118	13924	148	21904	178	31684
29	841	59	3481	89	7921	119	14161	149	22201	179	32041
30	900	60	3600	90	8100	120	14400	150	22500	180	32400

N.	Squa.	N.	Squa.	N.	Squa.	N.	Squa.	N.	Squa.
181	32761	211	44521	241	58081	271	73441	301	90601
182	33124	212	44944	242	58564	272	73984	302	91204
183	33489	213	45369	243	59049	273	74529	303	91809
184	33856	214	45796	244	59536	274	75076	304	92416
185	34225	215	46225	245	60025	275	75625	305	93025
186	34596	216	46656	246	60516	276	76176	306	93636
187	34969	217	47089	247	61009	277	76729	307	94249
188	35344	218	47524	248	61504	278	77284	308	94864
189	35721	219	47961	249	62001	279	77841	309	95481
190	36100	220	48400	250	62500	280	78400	310	96100
191	36481	221	48841	251	63001	281	78961	311	96721
192	36864	222	49284	252	63504	282	79524	312	97344
193	37249	223	49729	253	64009	283	80089	313	97969
194	37636	224	50176	254	64516	284	80656	314	98596
195	38025	225	50625	255	65025	285	81225	315	99225
196	38416	226	51076	256	65536	286	81796	316	99856
197	38809	227	51529	257	66049	287	82369	317	100489
198	39204	228	51984	258	66564	288	82944	318	101124
199	39601	229	52441	259	67081	289	82521	319	101761
200	40000	230	52900	260	67600	290	84100	320	102400
201	40401	231	53361	261	68121	291	84681	321	103041
202	40804	232	53824	262	68644	292	85264	322	103684
203	41209	233	54289	263	69169	293	85849	323	104329
204	41616	234	54756	264	69696	294	86436	324	104976
205	42025	235	55225	265	70225	295	87025	325	105625
206	42436	236	55696	266	70756	296	87616	326	106276
207	42849	237	56169	267	71289	297	88209	327	106929
208	43264	238	56644	268	71824	298	88804	328	107584
209	43681	239	57121	269	72361	299	89401	329	108241
210	44100	240	57600	270	72900	300	90000	330	108900

Dist.	¼ Point. Lat.	Dep	½ Point. Lat.	Dep.	¾ Point. Lat.	Dep.	1 Point. Lat.	Dep.	C.M.L. Dif.Lon
1	1. 0	0. 0	1. 0	0 1	1 0	0 1	1 0	0 2	1
2	2. 0	0. 1	2. 0	0 2	2 0	0 3	2 0	0 4	2
3	3. 0	0. 1	3. 0	0 3	3 0	0 4	2 9	0 6	3
4	4. 0	0. 2	4. 0	0 4	4 0	0 6	3 9	0 8	4
5	5. 0	0. 2	5. 0	0 5	4 9	0 7	4 9	1 0	5
6	6. 0	0. 3	6. 0	0 6	5 9	0 9	5 9	1 2	6
7	7. 0	0. 3	7. 0	0 7	6 9	1 0	6 9	1 4	7
8	8. 0	0. 4	8. 0	0 8	7 9	1 2	7 8	1 6	8
9	9. 0	0. 4	9. 0	0 9	8 9	1 3	8 8	1 8	9
10	10. 0	0. 5	9. 9	1 0	9 9	1 5	9 8	1 9	10
15	15. 0	0. 7	14. 9	1 5	14 8	2 2	14 7	2 9	15
20	20. 0	1. 0	19. 9	2 0	19 8	2 9	19 6	3 9	20
25	25. 0	1. 2	24. 9	2 4	24 7	3 7	24 5	4 9	25
30	30. 0	1. 5	29. 8	2 9	29 7	4 4	29 4	5 8	30
35	34. 9	1. 7	34. 8	3 4	34 6	5 1	31 3	6 8	35
40	39. 9	2. 0	39. 8	3 9	39 6	5 9	39 2	7 8	40
45	44. 9	2. 2	44. 8	4 4	44 5	6 6	44 1	8 8	45
50	49. 9	2. 4	49. 8	4 9	49 5	7 3	49 0	9 8	50
55	54. 9	2. 7	54. 7	5 4	54 4	8 1	53 9	10 7	55
60	59. 9	2. 9	59. 7	5 9	59 3	8 8	58 8	11 7	60
70	69. 9	3. 4	69. 7	6 9	69 2	10 3	68 7	13 7	70
80	79. 9	3. 9	79. 6	7 8	79 1	11 7	78 5	15 6	80
90	89. 9	4. 4	89. 6	8 8	89 0	13 2	88 3	17 6	90
100	99. 9	4. 9	99. 5	9 8	98 9	14 7	98 1	19 5	100
200	199.8	9. 8	199.0	19 6	197.3	29 4	196.2	39 0	200
300	299.7	14.7	298.5	29 4	296.7	44 1	294.3	58 5	300
400	399.6	19.6	398.0	39 2	395.6	58 8	392.4	78 0	400
500	499.5	24.5	497.5	49 0	494.5	73 5	490.5	97 5	500
Dist.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dif.Lon
	7 ¾ Point.		7½ Point.		7 ¼ Point.		7 Points.		C M.L.

Dist.	1 ¼ Point.		1 ½ Point.		1 ¾ Point.		2 Points.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Dif Lon
1	1 0	0 2	1 0	0 3	0 9	0 3	0 9	0 4	1
2	1 9	0 5	1 9	0 6	1 9	0 7	1 8	0 8	2
3	2 9	0 7	2 9	0 9	2 8	1 0	2 8	1 1	3
4	3 9	1 0	3 8	1 2	3 8	1 4	3 7	1 5	4
5	4 8	1 2	4 8	1 5	4 7	1 7	4 6	1 9	5
6	5 8	1 5	5 8	1 7	5 6	2 0	5 5	2 3	6
7	6 8	1 7	6 7	2 0	6 6	2 4	6 4	2 7	7
8	7 8	1 9	7 7	2 3	7 5	2 7	7 4	3 1	8
9	8 7	2 2	8 6	2 6	8 5	3 0	8 3	3 4	9
10	9 7	2 4	9 6	2 9	9 4	3 4	9 2	3 8	10
15	14 5	3 6	14 4	4 4	14 1	5 1	13 9	5 7	15
20	19 4	4 9	19 1	5 8	18 9	6 7	18 5	7 6	20
25	24 2	6 0	23 9	7 3	23 5	8 4	23 1	9 6	25
30	29 1	7 3	28 7	8 7	28 2	10 1	27 7	11 5	30
35	33 9	8 5	33 5	10 2	33 0	11 8	32 3	13 4	35
40	38 8	9 7	38 3	11 6	37 7	13 5	36 9	15 3	40
45	43 6	10 9	43 1	13 1	42 4	15 2	41 6	17 2	45
50	48 5	12 1	47 8	14 5	47 1	16 8	46 2	19 1	50
55	53 3	13 4	52 6	16 0	51 8	18 5	50 8	21 0	55
60	58 2	14 6	57 4	17 4	56 5	20 2	55 4	23 0	60
70	67 9	17 0	67 0	20 3	65 9	23 6	64 7	26 8	70
80	77 6	19 4	76 6	23 2	75 3	26 9	73 9	30 6	80
90	87 3	21 9	86 1	26 1	84 7	30 3	83 1	34 4	90
100	97 0	24 3	95 7	29 0	94 2	33 7	92 4	38 3	100
200	194.0	48 6	191.4	58 0	188.4	67 4	184.8	76 6	200
300	291.0	72 9	287.1	87 0	282.6	101.1	277.2	114.9	300
400	388.0	97 2	382.8	116.0	376.8	134.8	369.6	155.2	400
500	485.0	121 5	478.5	145.0	471.0	168.5	462.0	191.5	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif. Lon
	6 ¼ Point.		6 ½ Point.		6 ¾ Point.		6 Points.		C.M.L.

Dist.	2¼ Point.		2½ Point.		2¾ Point.		3 Points.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Dif. Lon.
1	0. 9	0. 4	0. 9	0. 5	0. 9	0. 5	0. 8	0. 6	1
2	1. 8	0. 9	1. 8	0. 9	1. 7	1. 0	1. 7	1. 1	2
3	2. 7	1. 3	2. 6	1. 4	2. 6	1. 5	2. 5	1. 7	3
4	3. 6	1. 7	3. 5	1. 9	3. 4	2. 1	3. 3	2. 2	4
5	4. 5	2. 1	4. 4	2. 4	4. 3	2. 6	4. 2	2. 8	5
6	5. 4	2. 6	5. 3	2. 8	5. 1	3. 1	5. 0	3. 3	6
7	6. 3	3. 0	6. 2	3. 3	6. 0	3. 6	5. 8	3. 9	7
8	7. 2	3. 4	7. 1	3. 8	6. 9	4. 1	6. 6	4. 4	8
9	8. 1	3. 8	7. 9	4. 2	7. 7	4. 6	7. 5	5. 0	9
10	9. 0	4. 3	8. 8	4. 7	8. 6	5. 1	8. 3	5. 6	10
15	13. 6	6. 4	13. 2	7. 1	12. 9	7. 7	12. 5	8. 3	15
20	18. 1	8. 5	17. 6	9. 4	17. 1	10. 3	16. 6	11. 1	20
25	22. 6	10. 7	22. 0	11. 8	21. 4	12. 8	20. 7	13. 9	25
30	27. 1	12. 8	26. 5	14. 1	25. 7	15. 1	24. 9	16. 7	30
35	31. 6	15. 0	30. 9	16. 5	30. 0	18. 0	29. 1	19. 4	35
40	36. 2	17. 1	35. 3	18. 9	34. 3	20. 6	33. 3	22. 2	40
45	40. 7	19. 2	39. 7	21. 2	38. 6	23. 1	37. 4	25. 0	45
50	45. 2	21. 4	44. 1	23. 6	40. 9	25. 7	41. 6	27. 8	50
55	49. 7	23. 5	48. 5	25. 9	47. 2	28. 3	45. 7	30. 6	55
60	54. 2	25. 9	52. 9	28. 3	51. 5	30. 8	49. 9	33. 3	60
70	63. 3	29. 6	61. 7	33. 0	60. 0	36. 0	58. 2	38. 9	70
80	72. 3	34. 2	70. 5	37. 7	68. 6	41. 1	66. 5	44. 4	80
90	81. 4	38. 5	79. 4	42. 5	77. 2	46. 3	74. 8	50. 0	90
100	90. 4	42. 7	88. 2	47. 1	85. 7	51. 3	83. 1	55. 6	100
200	180.8	85. 4	176.4	94. 2	171.4	102.6	166.2	111.2	200
300	271.2	128.1	264.6	141.3	257.1	153.9	249.3	166.8	300
400	361.6	170.8	352.8	188.4	342.8	205.2	332.4	222.4	400
500	452.0	213.5	441.0	235.5	428.5	256.5	415.5	278.0	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif. Lon.
	5¼ Point.		5½ Point.		5¾ Point.		5 Points.		C.M.L.

Dist.	3¼ Point		3½ Point		3¾ Point		4 Points		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Dif. Lon
1	0. 8	0. 6	0. 8	0. 6	0. 7	0. 7	0. 7	0. 7	1
2	1. 6	1. 2	1. 5	1. 3	1. 5	1. 3	1. 4	1. 4	2
3	2. 4	1. 8	2. 3	1. 9	2. 2	2. 0	2. 1	2. 1	3
4	3. 2	2. 9	3. 1	2. 5	3. 0	2. 7	2. 8	2. 8	4
5	4. 0	3. 0	3. 9	3. 2	3. 7	3. 4	3. 5	3. 5	5
6	4. 8	3. 6	4. 6	3. 8	4. 4	4. 0	4. 2	4. 2	6
7	5. 6	4. 2	5. 4	4. 4	5. 2	4. 7	4. 9	4. 9	7
8	6. 4	4. 8	6. 2	5. 1	5. 9	5. 4	5. 7	5. 7	8
9	7. 2	5. 4	7. 0	5. 7	6. 7	6. 0	6. 4	6. 4	9
10	8. 0	6. 0	7. 7	6. 3	7. 4	6. 7	7. 1	7. 1	10
15	12. 0	8. 9	11. 6	9. 5	11. 1	10. 1	10. 6	10. 6	15
20	16. 1	11. 9	15. 5	12. 7	14. 8	13. 4	14. 1	14. 1	20
25	20. 1	14. 9	19. 3	15. 9	18. 5	16. 8	17. 7	17. 7	25
30	24. 1	17. 9	23. 2	19. 0	22. 2	20. 1	21. 2	21. 2	30
35	28. 1	20. 8	27. 0	22. 2	25. 9	23. 5	24. 7	24. 7	35
40	32. 1	23. 8	30. 9	25. 4	29. 6	26. 9	28. 3	28. 3	40
45	36. 1	26. 8	34. 8	28. 5	33. 3	30. 2	31. 8	31. 8	45
50	40. 2	29. 8	38. 6	31. 7	37. 0	33. 6	35. 3	35. 3	50
55	44. 2	32. 8	42. 5	34. 9	40. 7	36. 9	38. 9	38. 9	55
60	48. 3	35. 7	46. 4	38. 1	44. 5	40. 3	42. 4	42. 4	60
70	56. 2	41. 7	54. 1	44. 4	51. 9	47. 0	49. 5	49. 5	70
80	64. 3	47. 7	61. 8	51. 7	59. 3	53. 7	56. 6	56. 6	80
90	72. 3	53. 6	69. 6	57. 1	66. 7	60. 4	63. 6	63. 6	90
100	80. 3	59. 6	77. 3	63. 4	74. 1	67. 2	70. 7	70. 7	100
200	160.6	119.2	154.6	126.8	148.2	134.4	141.4	141.4	200
300	240.9	178.8	231.9	190.2	222.3	201.6	212.1	212.1	300
400	321.2	238.4	309.2	253.6	296.4	268.8	282.8	232.8	400
500	401.5	298.0	386.5	317.0	370.5	336.0	353.5	353.5	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif. Lon
	4¾ Point		4½ Point		4¼ Point		4 Points		C.M.L.

Dist.	1 Degree		2 Degrees		3 Degrees		4 Degrees		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Dif.Lon
1	1. 0	0. 0	1. 0	0. 0	1. 0	0. 0	1. 0	0. 1	1
2	2. 0	0. 0	2. 0	0. 1	2. 0	0. 1	2. 0	0. 1	2
3	3. 0	0. 1	3. 0	0. 1	3. 0	0. 2	3. 0	0. 2	3
4	4. 0	0. 1	4. 0	0. 1	4. 0	0. 2	4. 0	0. 3	4
5	5. 0	0. 1	5. 0	0. 2	5. 0	0. 3	5. 0	0. 3	5
6	6. 0	0. 1	6. 0	0. 2	6. 0	0. 4	6. 0	0. 4	6
7	7. 0	0. 1	7. 0	0. 2	7. 0	0. 5	7. 0	0. 5	7
8	8. 0	0. 1	8. 0	0. 3	8. 0	0. 6	8. 0	0. 6	8
9	9. 0	0. 2	9. 0	0. 3	9. 0	0. 6	9. 0	0. 6	9
10	10. 0	0. 2	10 0	0. 4	10. 0	0. 7	10. 0	0. 7	10
15	15. 0	0. 3	15 0	0. 5	15. 0	0. 8	15. 0	1. 0	15
20	20. 0	0. 4	20 0	0. 7	20. 0	1. 0	19. 9	1. 4	20
25	25. 0	0. 4	25 0	0. 9	25. 0	1. 3	24. 9	1. 7	25
30	30. 0	0. 5	30. 0	1. 1	30. 0	1. 6	29. 9	2. 1	30
35	35. 0	0. 6	35. 0	1. 2	34. 9	1. 8	34. 9	2. 4	35
40	40. 0	0. 7	40. 0	1. 4	39. 9	2. 1	39. 9	2. 8	40
45	45. 0	0. 8	45. 0	1. 6	44. 9	2. 4	44. 9	3. 1	45
50	50. 0	0. 9	50. 0	1. 8	49. 9	2. 6	49. 9	3. 5	50
55	55. 0	1. 0	55. 0	1. 9	54. 9	2. 9	54. 9	3. 8	55
60	60. 0	1. 0	60. 0	2. 1	59. 9	3. 1	59. 8	4. 2	60
70	70. 0	1. 2	69. 9	2. 4	69. 9	2. 7	69. 8	4. 9	70
80	80. 0	1. 4	79. 9	2. 8	79. 9	4. 2	79. 8	5. 6	80
90	90. 0	1. 6	89. 9	3. 1	89. 9	4. 7	89. 8	6. 3	90
100	100.0	1. 7	99. 9	3. 5	99. 9	5. 2	99. 8	7. 0	100
200	200.0	3. 4	199.8	7. 0	199.8	10. 4	199.6	14. 0	200
300	300.0	5. 1	299.7	10. 4	299.7	15. 6	299.4	21. 0	300
400	400.0	6. 8	399.6	14. 0	399.6	20. 8	396.2	28. 0	400
500	500 0	8. 5	499.5	17. 5	499.5	25. 0	499.0	35. 0	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif.Lon
	89 Degrees		88 Degrees		87 Degrees		86 Degrees		C.M.L.

Dist.	5 Degrees.		6 Degrees.		7 Degrees.		8 Degrees.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	*Dif. Lon*
1	1 0	0 1	1 0	0 1	1 0	0 1	1 0	0 1	1
2	2 0	0 2	2 0	0 2	2 0	0 2	2 0	0 3	2
3	3 0	0 3	3 0	0 3	3 0	0 4	3 0	0 4	3
4	4 0	0 3	4 0	0 4	4 0	0 5	4 0	0 6	4
5	5 0	0 4	5 0	0 5	5 0	0 6	4 9	0 7	5
6	6 0	0 5	6 0	0 6	6 0	0 7	5 9	0 8	6
7	7 0	0 6	7 0	0 7	6 9	0 8	6 9	1 0	7
8	8 0	0 7	8 0	0 8	7 9	1 0	7 9	1 1	8
9	9 0	0 8	8 9	0 9	8 9	1 1	8 9	1 2	9
10	10 0	0 9	9 9	1 0	9 9	1 2	9 9	1 4	10
15	14 9	1 3	14 9	1 6	14 9	1 8	14 8	2 1	15
20	19 9	1 7	19 9	2 1	19 8	2 4	19 8	2 8	20
25	24 9	2 2	24 9	2 6	24 8	3 0	24 8	3 5	25
30	29 9	2 6	29 8	3 1	29 8	3 7	29 7	4 2	30
35	34 9	3 1	34 8	3 7	34 7	4 3	34 7	4 9	35
40	39 8	3 5	39 8	4 2	39 7	4 9	39 6	5 6	40
45	44 8	3 9	44 7	4 7	44 7	5 5	44 6	6 3	45
50	49 8	4 4	49 7	5 2	49 6	6 1	49 5	7 0	50
55	54 8	4 8	54 7	5 8	54 6	6 7	54 5	7 6	55
60	59 8	5 2	59 7	6 3	59 5	7 3	59 4	8 3	60
70	69 7	6 1	69 6	7 3	69 5	8 5	69 3	9 7	70
80	79 7	7 0	79 6	8 4	79 4	9 8	79 2	11 1	80
90	89 7	7 9	89 5	9 4	89 3	11 1	89 1	12 5	90
100	99 6	8 7	99 4	10 4	99 2	12 2	99 0	13 9	100
200	199.2	17 4	198.8	20 8	198.4	24 4	198.0	27 8	200
300	298.8	26 1	298.2	31 2	297.6	36 6	297.0	41 7	300
400	398.4	34 8	397.6	41 6	396.8	48 8	396.0	55 6	400
500	498.0	43 5	497.0	52 0	496.0	61 0	495.0	69 5	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	*Dif. Lon*
	85 Degrees		84 Degrees		83 Degrees		82 Degrees		C.M.L.

Dist.	9 Degrees.		10 Degr.		11 Degr.		12 Degr.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Dif.Lon
1	1 0	0 2	1 0	0 2	1 0	0 2	1 0	0 2	1
2	2 0	0 3	2 0	0 3	2 0	0 4	2 0	0 4	2
3	3 0	0 5	2 9	0 5	2 9	0 6	2 9	0 6	3
4	3 9	0 6	3 9	0 7	3 9	0 8	3 9	0 8	4
5	4 9	0 8	5 9	0 9	4 9	0 9	4 9	1 0	5
6	5 9	0 9	5 9	1 0	5 9	1 1	5 9	1 2	6
7	6 9	1 1	6 9	1 2	6 9	1 3	6 8	1 5	7
8	7 9	1 2	7 9	1 4	7 8	1 5	7 8	1 7	8
9	8 9	1 4	8 9	1 6	8 8	1 7	8 8	1 9	9
10	9 9	1 6	9 8	1 7	9 8	1 9	9 8	2 1	10
15	14 8	2 3	14 8	2 6	14 7	2 9	14 7	3 1	15
20	19 7	3 1	19 7	3 5	19 6	3 8	19 6	4 2	20
25	24 7	3 9	24 6	4 3	24 5	4 8	24 4	5 2	25
30	29 6	4 7	29 5	5 2	29 4	5 7	29 3	6 2	30
35	34 6	5 5	34 5	6 1	34 4	6 7	34 2	7 3	35
40	39 5	6 3	39 4	6 9	39 3	7 6	39 1	8 3	40
45	44 4	7 0	44 3	7 8	44 2	8 6	44 0	9 4	45
50	49 4	7 8	49 2	8 7	49 1	9 5	48 9	10 4	50
55	54 3	8 6	54 2	9 5	54 0	10 5	53 8	11 4	55
60	59 3	9 4	59 1	10 4	58 9	11 4	58 7	12 5	60
70	69 1	10 9	68 9	12 2	68 7	13 4	68 5	14 5	70
80	79 0	12 5	78 8	13 9	78 5	15 3	78 2	16 6	80
90	88 9	13 3	88 6	15 6	88 3	17 2	88 0	18 7	90
100	98 8	15 6	98 5	17 4	98 2	19 1	97 8	20 8	100
200	197.6	31 2	197.0	34 8	196.4	38 2	195.6	41 6	200
300	296.4	46 8	295.5	52 2	294.6	57 3	293.4	62 4	300
400	395.2	62 4	394.0	69 6	392.8	76 4	391.2	83 2	400
500	494.0	78 0	492.5	87 0	491.0	95 5	489.0	104.0	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif.Lon
	81 Degr.		80 Degr.		79 Degr.		78 Degr.		C.M.L.

Dist.	13 Degr.		14 Degr.		15 Degr.		16 Degr.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	*Dif.Lon*
1	1 0	0 2	1 0	0 2	1 0	0 3	1 0	0 3	1
2	2 9	0 4	1 9	0 5	1 9	0 5	1 9	0 5	2
3	2 9	0 7	2 9	0 7	2 9	0 8	2 9	0 8	3
4	3 9	0 9	3 9	1 0	3 9	1 0	3 8	1 1	4
5	4 9	1 1	4 8	1 2	4 8	1 3	4 8	1 4	5
6	5 8	1 3	5 8	1 4	5 8	1 5	5 8	1 6	6
7	6 8	1 6	6 8	1 7	6 8	1 8	6 8	1 9	7
8	7 8	1 8	7 8	1 9	7 7	2 1	7 7	2 2	8
9	8 8	2 0	8 7	2 2	8 7	2 3	8 6	2 6	9
10	9 7	2 2	9 7	2 4	9 7	2 6	9 6	2 8	10
15	14 6	3 4	14 5	3 6	14 5	3 9	13 4	1 1	15
20	19 5	4 5	19 4	4 8	19 3	5 2	19 2	5 5	20
25	24 3	5 6	24 3	6 0	24 1	6 5	24 0	6 9	25
30	29 2	6 7	29 1	7 3	29 0	7 8	28 8	8 3	30
35	34 1	7 9	34 0	8 5	33 8	9 0	33 6	9 6	35
40	39 0	9 0	38 8	9 7	38 6	10 3	38 4	11 0	40
45	43 8	10 1	43 7	11 0	43 5	11 6	43 2	12 4	45
50	48 7	11 2	48 5	12 1	48 3	12 9	48 1	13 8	50
55	53 6	12 4	53 4	13 3	53 1	14 2	52 9	15 2	55
60	58 5	13 5	58 2	14 5	58 0	15 5	57 7	16 5	60
70	68 2	15 7	67 9	16 9	67 6	18 1	67 3	19 3	70
80	77 9	18 0	77 6	19 3	77 3	20 7	76 9	22 0	80
90	87 7	20 2	87 3	21 8	86 9	23 2	86 5	24 8	90
100	97 4	22 5	97 0	24 2	96 6	25 9	96 1	27 6	100
200	194.8	45 0	194.0	48 4	193.2	51 8	192.2	55 2	200
300	292.2	67 5	291.0	72 6	289.8	77 7	288.3	82 8	300
400	389 6	90 0	388.0	96 8	386.4	103. 6	384.4	110.4	400
500	487 0	112.5	485.0	121.0	483.0	129. 5	480.5	138.0	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	*Dif.Lon*
	77 Degrees		76 Degrees		75 Degrees		74 Degrees		C.M.L.

Dist.	17 Degr.		18 Degr.		19 Degr.		20 Degr.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Dif.Lon
1	1 0	0 3	0 9	0 3	0 9	0 3	0 9	0 3	1
2	1 9	0 6	1 9	0 6	1 9	0 6	1 9	0 7	2
3	2 9	0 9	2 8	0 9	2 8	1 0	2 8	1 0	4
4	3 8	1 2	3 8	1 2	3 8	1 3	3 8	1 4	4
5	4 8	1 5	4 8	1 5	4 7	1 6	4 7	1 7	5
6	5 7	1 7	5 7	1 8	5 7	1 9	5 6	2 0	6
7	6 7	2 0	6 7	2 2	6 6	2 3	6 6	2 4	7
8	7 6	2 3	7 6	2 5	7 6	2 6	7 5	2 7	8
9	8 6	2 6	8 6	2 8	8 5	2 9	8 5	3 1	9
10	9 6	2 9	9 5	3 1	9 5	3 3	9 4	3 4	10
15	14 3	4 4	14 3	4 6	14 2	4 9	14 1	5 1	15
20	19 1	5 8	19 0	6 2	18 9	6 5	18 8	6 8	20
25	23 9	7 3	23 8	7 7	23 6	8 1	23 5	8 5	25
30	28 7	8 8	28 5	9 3	28 4	9 8	28 2	10 3	30
35	33 5	10 2	33 3	10 8	33 1	11 4	32 9	12 0	35
40	38 2	11 7	38 0	12 4	37 8	13 0	37 6	13 7	40
45	43 0	13 1	42 8	13 9	42 6	14 6	42 3	15 4	45
50	47 8	14 6	47 5	15 4	47 3	16 3	47 0	17 1	50
55	52 6	16 1	52 3	17 0	52 0	17 9	51 7	18 8	55
60	57 4	17 5	57 1	18 5	56 7	19 5	56 4	20 5	60
70	66 9	20 5	66 6	21 6	66 2	22 8	65 8	23 9	70
80	76 5	23 4	76 1	24 7	75 6	26 0	75 2	27 4	80
90	86 1	26 3	85 6	27 8	85 1	29 3	84 6	30 8	90
100	95 6	29 2	95 1	30 9	94 5	32 6	94 0	34 2	100
200	191.2	58 4	190.2	61 8	189.0	65 2	188.0	68 4	200
300	286.8	87 6	285.3	92 7	283.5	97 8	282.0	102.6	300
400	382.4	116.8	380.4	123.6	378.0	130.4	376.0	136.8	400
500	478 0	146.0	475.5	154.5	472.5	163.0	470.0	171.0	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif.Lon
	73 Degr.		72 Degr.		71 Degr.		70 Degr.		C. M. L

Dist.	21 Degr.		22 Degr.		23 Degr.		24 Degr.		C.M.L.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Dif Lon	
1	0. 9	0. 4	0. 9	0 4	0 9	0 4	0 9	0 4		1
2	1. 9	0. 7	1. 8	0 7	1 8	0 8	1 8	0 8		2
3	2. 8	1. 1	2. 8	1 1	2 8	1 2	2 8	1 2		3
4	3. 7	1. 4	3. 7	1 5	3 7	1 6	3 6	1 6		4
5	4. 7	1. 8	4. 6	1 9	4 6	1 9	4 6	2 0		5
6	5. 6	2. 1	5. 6	2 2	5 5	2 3	5 5	2 4		6
7	6. 5	2. 5	6. 5	2 6	6 4	2 7	6 4	2 8		7
8	7. 5	2. 9	7. 4	3 0	7 4	3 1	7 3	3 2		8
9	8. 4	3. 2	8. 3	3 4	8 3	3 5	8 2	3 7		9
10	9. 3	3. 6	9. 3	3 7	9 2	3 9	9 1	4 1		10
15	14. 0	5. 4	13. 9	5 6	13 8	5 8	13 7	6 1		15
20	18. 7	7. 2	18. 5	7 5	18 4	7 7	18 3	8 1		20
25	23. 3	9. 0	23. 2	9 4	23 0	9 8	22 8	10 2		25
30	28. 0	10. 7	27. 8	11 2	27 6	11 7	27 4	12 2		30
35	32. 7	12. 5	32. 4	13 1	32 2	13 7	32 0	14 2		35
40	37. 3	14. 3	37. 1	15 0	36 8	15 6	36 5	16 3		40
45	42. 0	16. 1	41. 7	16 8	41 4	17 6	41 1	18 3		45
50	46. 7	17. 9	46. 4	18 7	46 0	19 5	45 7	20 3		50
55	51. 3	19. 7	51. 0	20 6	50 6	21 5	50 2	22 4		55
60	56. 0	21. 5	55. 6	22 5	55 2	23 4	54 8	24 4		60
70	65. 3	25. 1	64. 9	26 2	64 4	27 3	63 9	28 5		70
80	74. 7	28. 7	74. 2	30 0	73 6	31 3	73 1	32 5		80
90	84. 0	32. 3	83. 4	33 7	82 8	35 2	82 2	36 6		90
100	93. 4	35. 8	92. 7	37 5	92 0	39 1	91 4	40 7		100
200	186.8	71. 6	185.4	75 0	184.0	78 2	182.8	81 4		200
300	280.2	107.4	278.1	112.5	276.0	117.3	274.2	122.1		300
400	373.6	143.2	370.8	150.0	368.0	156.4	365.6	162.8		400
500	467.0	179.0	463.5	187.5	460 0	195.5	457.0	203.5		500
Dist.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dif. Lon	
	69 Degr.		68 Degr.		67 Degr.		66 Degr.		C M L.	

Dist.	25 Degr.		26 Degr.		27 Degr.		28 Degr.		C.M.L.
	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Dif.Lon
1	0 9	0 4	0 9	0 4	0 9	0 4	0 9	0 5	1
2	1 8	0 8	1 8	0 9	1 8	0 9	1 8	0 9	2
3	2 7	1 3	2 7	1 3	2 7	1 4	2 6	1 4	3
4	3 6	1 7	3 6	1 7	3 6	1 8	3 5	1 9	4
5	4 5	2 1	4 5	2 2	4 5	2 3	4 4	2 3	5
6	5 4	2 5	5 4	2 6	5 3	2 7	5 3	2 8	6
7	6 3	3 0	6 3	3 1	6 2	3 2	6 2	3 3	7
8	7 2	3 4	7 2	3 5	7 1	3 6	7 1	3 8	8
9	8 0	3 8	8 1	3 9	8 0	4 1	7 9	4 2	9
10	9 1	4 2	9 0	4 4	8 9	4 5	8 8	4 7	10
15	13 6	6 3	13 5	6 6	13 4	6 8	13 2	7 0	15
20	18 1	8 4	18 0	8 8	17 8	9 1	17 7	9 4	20
25	22 7	10 6	22 5	11 0	22 3	11 3	22 1	11 7	25
30	27 2	12 7	27 0	13 1	26 7	13 6	26 5	14 1	30
35	31 7	14 8	31 5	15 3	31 2	15 9	30 9	16 4	35
40	36 2	16 9	35 9	17 5	35 6	18 2	35 3	18 8	40
45	40 8	19 0	40 4	19 7	40 1	20 4	39 7	21 1	45
50	45 3	21 8	44 9	21 9	44 5	22 7	44 1	23 5	50
55	49 8	23 2	49 4	24 1	49 0	25 0	48 6	25 8	55
60	54 4	25 4	53 9	26 3	53 5	27 2	53 0	28 2	60
70	63 4	29 6	62 9	30 7	62 4	31 8	61 8	32 9	70
80	72 5	33 8	71 9	35 1	71 3	36 3	70 6	37 6	80
90	81 6	38 0	80 9	39 4	80 2	40 9	79 5	42 2	90
100	90 6	42 3	89 9	43 8	89 1	45 4	88 3	46 9	100
200	181.2	84 6	179.8	87 6	178.2	90 8	176.6	93 8	200
300	271.8	126.9	269.7	131.4	267.3	136.2	264.9	140.7	300
400	362.4	169.2	359.6	175.2	356.4	181.6	353.2	187.6	400
500	453.0	211.5	449.5	219.0	445.5	227.0	441.5	334.5	500
Dist.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat	Dif.Lon
	65 Degr.		64 Degr.		63 Degr.		62 Degr.		C.M.L.

Dist.	29 Degr.		30 Degr.		31 Degr.		32 Degr.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	*Dif. Lon*
1	0. 9	0. 5	0. 9	0. 5	0. 9	0. 5	0 8	0 5	1
2	1. 7	1. 0	1. 7	1. 0	1. 7	1. 0	1 7	1 1	2
3	2. 6	1. 4	2. 6	1. 5	2. 6	1. 5	2 5	1 6	3
4	3. 5	1. 9	3. 5	2. 0	3. 4	2. 1	3 4	2 1	4
5	4. 4	2. 4	4. 3	2. 5	4. 3	2. 6	4 2	2 6	5
6	5. 2	2. 9	5. 2	3. 0	5. 1	3. 1	5 1	3 2	6
7	6. 1	3. 4	6. 1	3. 5	6. 1	3. 6	5 9	3 7	7
8	7. 0	3. 9	6. 9	4. 0	6. 9	4. 1	6 8	4 2	8
9	7. 9	4. 4	7. 8	4. 5	7. 7	4. 6	7 6	4 8	9
10	8. 7	4. 8	8. 7	5. 0	8. 6	5. 1	8 5	5 3	10
15	13. 1	7. 3	13. 0	7. 5	12. 9	7. 7	12 7	7 9	15
20	17. 5	9. 7	17. 3	10. 0	17. 1	10. 3	17 0	10 6	20
25	21. 9	12. 1	21. 6	12. 5	21. 4	12. 9	21 2	13 2	25
30	26. 2	14. 5	26. 0	15. 0	25. 7	15. 4	25 4	15 9	30
35	30. 6	17. 0	30. 3	17. 5	30. 0	18. 0	39 7	18 5	35
40	35. 0	19. 4	34. 6	20. 0	34. 3	20. 6	33 9	21 2	40
45	39. 3	21. 8	39. 0	22. 5	38. 6	23. 2	38 1	23 8	45
50	43. 7	24. 2	43. 3	25. 0	42. 9	25. 7	42 4	26 5	50
55	48. 1	26. 7	47. 6	27. 5	47. 1	28. 3	46 6	29 1	55
60	52. 5	29. 1	52. 0	30. 0	51. 4	30. 9	50 9	31 8	60
70	61. 2	33. 9	60. 6	35. 0	60. 0	36. 0	59 4	37 1	70
80	70. 0	38. 8	69. 3	40. 0	68. 6	41. 2	67 8	42 4	80
90	78. 7	43. 6	77. 9	45. 0	77. 1	46. 3	76 3	47 7	90
100	87. 5	48. 5	86. 6	50. 0	85. 7	51. 5	84 8	53 0	100
200	175.0	97. 0	173.2	100.0	171.4	103.0	169 6	106.0	200
300	262.5	145.5	259.8	150.0	257.1	154.5	254.4	159.0	300
400	350.0	194.0	346.4	200.0	342.8	206.0	339.2	212.0	400
500	437.5	242.5	433.0	250.0	427.5	257.5	424.0	265.0	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	*Dif. Lon*
	61 Degr.		60 Degr.		59 Degr.		58 Degr.		C.M.L.

Dist.	33 Degr.		34 Degr.		35 Degr.		36 Degr.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Dif. Lon
1	0. 8	0. 5	0. 8	0. 6	0. 8	0. 6	0. 8	0. 6	1
2	1. 7	1. 1	1. 7	1. 1	1. 6	1. 1	1. 6	1. 2	2
3	2. 5	1. 6	2. 5	1. 7	2. 5	1. 7	2. 4	1. 8	3
4	3. 4	2. 2	3. 3	2. 2	3. 3	2. 3	3. 2	2. 3	4
5	4. 2	2. 7	4. 2	2. 8	4. 1	2. 9	4. 0	2. 9	5
6	5. 0	3. 3	5. 0	3. 4	4. 9	3. 4	4. 8	3. 5	6
7	5. 9	3. 8	5. 8	3. 9	5. 7	4. 0	5. 7	4. 1	7
8	6. 7	4. 4	6. 6	4. 5	6. 5	4. 6	6. 5	4. 7	8
9	7. 5	4. 9	7. 5	5. 0	7. 4	5. 2	7. 3	5. 3	9
10	8. 4	5. 4	8. 3	5. 6	8. 2	5. 7	8. 1	5. 9	10
15	12. 6	8. 2	12. 4	8. 4	12. 3	8. 6	12. 1	8. 8	15
20	16. 8	10. 9	16. 6	11. 2	16. 4	11. 5	16. 2	11. 8	20
25	21. 0	13. 6	20. 7	14. 0	20. 5	14. 3	20. 1	14. 7	25
30	25. 2	16. 3	24. 9	16. 8	24. 6	17. 2	24. 3	17. 6	30
35	29. 4	19. 1	29. 0	19. 6	28. 7	20. 1	28. 3	20. 6	35
40	33. 6	21. 8	33. 2	22. 4	32. 8	22. 9	32. 4	23. 5	40
45	37. 7	24. 5	37. 3	25. 2	36. 9	25. 8	36. 4	26. 4	45
50	41. 9	27. 2	41. 4	28. 0	41. 0	28. 7	40. 4	29. 4	50
55	46. 1	30. 0	45. 6	30. 7	45. 1	31. 5	44. 5	32. 3	55
60	50. 3	32. 7	49. 7	33. 5	49. 1	34. 4	48. 5	35. 3	60
70	58. 7	38. 1	58. 0	39. 1	57. 3	40. 1	56. 6	41. 1	70
80	67. 1	43. 6	66. 3	44. 7	65. 5	45. 9	64. 7	47. 0	80
90	75. 5	49. 0	74. 6	50. 3	73. 7	51. 6	72. 8	52. 9	90
100	83. 9	54. 5	82. 9	55. 9	81. 9	57. 4	80. 9	58. 8	100
200	167.8	109.0	165.8	111.8	163.8	114.8	161.8	117.6	200
300	251.7	163.5	248.7	167.7	245.7	172.2	242.7	176.4	300
400	335.6	218.0	331.6	223.6	327.6	229.6	323.6	235.2	400
500	419.5	272.5	414.5	279.5	409.5	287.0	404.5	284.0	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif. Lon
	57 Degrees		56 Degrees		55 Degrees		54 Degrees		C.M.L.

Dist.	37 Degr. Lat.	37 Degr. Dep.	38 Degr. Lat.	38 Degr. Dep.	39 Degr. Lat.	39 Degr. Dep.	40 Degr. Lat.	40 Degr. Dep.	C.M.L. Dif. Lon
1	0 8	0 6	0 8	0 6	0 8	0 7	0 8	0 6	1
2	1 6	1 2	1 6	1 2	1 5	1 3	1 5	1 3	2
3	2 4	1 8	2 4	1 8	2 3	1 9	2 3	1 9	3
4	3 2	2 4	3 1	2 5	3 5	2 5	3 1	2 6	4
5	4 0	3 0	3 9	3 1	3 9	3 1	3 8	3 2	5
6	4 8	3 6	4 7	3 7	4 6	3 9	4 6	3 9	6
7	5 6	4 2	5 5	4 3	5 4	4 4	5 4	4 5	7
8	6 4	4 8	6 3	4 9	6 2	5 0	6 1	5 1	8
9	7 2	5 4	7 1	5 5	7 0	5 7	6 9	5 8	9
10	8 0	6 0	7 9	6 2	7 8	6 3	7 7	6 4	10
15	12 0	9 0	11 8	9 3	11 6	9 4	11 5	9 6	15
20	16 0	12 0	15 8	12 3	15 5	12 0	15 3	12 9	20
25	20 0	15 0	19 7	15 4	19 4	15 9	19 1	16 1	25
30	24 0	18 0	23 6	18 5	23 3	18 9	23 0	19 3	30
35	27 9	21 1	27 6	21 5	27 2	22 0	26 8	22 5	35
40	31 9	24 1	31 5	24 6	31 1	25 2	30 6	25 7	40
45	35 9	27 1	35 5	27 7	35 0	28 3	34 5	28 9	45
50	39 9	30 1	39 4	30 8	38 9	31 5	38 3	32 1	50
55	43 9	33 1	43 3	33 9	42 7	34 6	42 1	35 4	55
60	47 9	36 1	47 3	36 9	46 6	37 8	46 0	38 6	60
70	55 9	42 1	55 2	43 1	54 4	44 0	53 6	45 0	70
80	63 9	48 1	63 0	49 3	62 2	50 3	61 3	51 4	80
90	71 9	54 2	70 9	55 4	69 9	56 6	68 9	57 4	90
100	79 9	60 2	78 8	61 6	77 7	62 9	76 6	64 3	100
200	159.8	120.4	157.6	123.2	155.4	125.8	153.2	128.6	200
300	239.7	180.6	236.4	184.8	232.1	188.7	229.8	192.9	300
400	319.6	240.8	315.2	246.4	310.8	251.6	306.4	257.2	400
500	399.5	301.0	394.0	308.0	388.5	314.5	383.0	321.5	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif. Lon
	53 Degr.		52 Degr.		51 Degr.		50 Degr.		C.M.L.

Dist.	41 Degr.		42 Degr.		43 Degr.		44 Degr.		C.M.L.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Dif.Lon
1	0. 7	0. 7	0. 7	0. 7	0. 7	0. 7	0. 7	0. 7	1
2	1. 5	1. 3	1. 5	1. 3	1. 5	1. 4	1. 4	1. 4	2
3	2. 3	2. 0	2. 2	2. 0	2. 2	2. 0	2. 2	2. 1	3
4	3. 0	2. 6	3. 0	2. 7	2. 9	2. 7	2. 9	2. 8	4
5	3. 8	3. 3	3. 7	3. 3	3. 6	3. 4	3. 6	3. 5	5
6	4. 5	3. 9	4. 5	4. 0	4. 4	4. 1	4. 3	4. 2	6
7	5. 3	4. 6	5. 2	4. 7	5. 1	4. 8	5. 0	4. 9	7
8	6. 0	5. 2	5. 9	5. 3	5. 8	5. 5	5. 7	5. 6	8
9	6. 8	5. 9	6. 7	6. 0	6. 6	6. 1	6. 5	6. 2	9
10	7. 5	6. 6	7. 4	6. 7	7. 3	6. 8	7. 2	6. 9	10
15	11. 3	9. 8	11. 2	10. 0	11. 0	10. 2	10. 8	10. 4	15
20	15. 1	13. 1	14. 9	13. 4	14. 6	13. 6	14. 4	13. 9	20
25	18. 9	16. 4	18. 6	16. 7	18. 3	17 1	18. 0	17. 4	25
30	22. 6	19. 7	22. 3	20. 1	21. 9	20. 5	21. 6	20. 8	30
35	26. 4	23. 0	26. 0	23. 4	25. 6	23. 9	25. 2	24. 3	35
40	30. 2	26. 2	29. 7	26. 8	29. 2	27. 3	28. 8	27. 8	40
45	34. 0	29. 5	33. 4	30. 1	32. 9	30. 7	32. 4	31. 3	45
50	37. 7	32 8	37. 2	33. 5	36. 6	34 1	36. 0	34. 7	50
55	41 5	36. 0	40. 9	36. 8	40. 2	37. 5	39. 6	38. 2	55
60	45. 3	39. 4	44. 6	40. 1	43. 8	40. 9	43. 2	41. 7	60
70	52. 8	45. 9	52. 0	46. 8	51. 2	47. 7	50. 3	48. 6	70
80	60. 4	52. 5	59. 4	53. 5	58. 5	54. 6	57. 5	55. 6	80
90	67. 9	59. 0	66. 9	60. 2	65. 8	61. 4	64. 7	62. 5	90
100	75. 5	65. 6	74. 3	66. 9	73. 1	68. 2	71. 9	69. 5	100
200	151.0	131.2	148.6	133.8	146.2	136.4	143.8	139.0	200
300	226.5	196.8	222.9	200.7	219.3	204.6	215.7	208.5	300
400	302.0	262.4	297.2	267.6	292.4	272 8	287.6	278.0	400
500	377.5	328.0	371.5	334 5	365.5	341.0	359.5	347.5	500
Dist.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dif.Lon
	49 Degr.		48 Degr.		47 Degr.		46 Degr.		C.M.L.

No. 11. *A TABLE shewing the Distance Run, Diff. Lat. or Dep. for every Point, ½ or ¼ Point of the Compass.*

Angle of the Course in Degrees and Decimals.	*Distance*	*Diff. Lat. or Departure.*
2.8125	20.39	20.37
5.625	10.21	10.15
8.4375	6.82	6.74
11.25	5.13	5 03
14.0625	4.14	3.87
16 875	3.41	3.37
19.6875	2.97	2.797
22.5	2.614	2 416
25.3125	2.340	2.115
28.125	2.122	1.871
30.9373	1.945	1.669
33.75	1.800	1.496
36.5625	1.678	1.348
39.375	1.576	1.218
42.1875	1.462	1.153
45.	1.000	1.000

No. 12. *A Table shewing the Reduction of Minutes into Decimals, and the contrary.*

M.	*Decim.*	M	*Decim.*
1	.0167	15	.2500
2	.0333	16	.2667
3	.0500	17	.2833
4	.0667	18	.3000
5	.0833	19	.3167
6	.1000	20	.3333
7	.1167	21	.3500
8	.1333	22	.3667
9	.1500	23	.3833
10	.1667	24	.4000
11	.1833	25	.4167
12	.2000	26	.4333
13	.2167	27	.4500
14	.2333	28	.4677

The Table of Decimals continu'd.

M.	*Decim.*	M.	*Decim.*	M.	*Decim.*	M.	*Decim.*
29	.4833	37	.6167	45	.7500	53	.8833
30	.5000	38	.6333	46	.7667	54	.9000
31	.5167	39	.6500	47	.7833	55	.9167
32	.7333	40	.6667	48	.8000	56	.9333
33	.5500	41	.6833	49	.8167	57	.9500
34	.5667	42	.7700	50	.8333	58	.9667
35	.5833	43	.7167	51	.8500	59	.9833
36	.6000	44	7333	52	.8667	60	.10000

Deg.	Sec.	Deg.	Sec.	Deg.	Sec.
0	1000	31	1167	62	2130
1	1000	32	1179	63	2203
2	1001	33	1192	64	2281
3	1001	34	1206	65	2366
4	1002	35	1221	66	2458
5	1004	36	1236	67	2559
6	1005	37	1252	68	2669
7	1007	38	1269	69	2790
8	1010	39	1287	70	2924
9	1015	40	1305	71	3071
10	1019	41	1325	72	3236
11	1022	42	1346	73	3420
12	1026	43	1367	74	3628
13	1026	44	1390	75	3864
14	1031	45	1414	76	4133
15	1035	46	1439	77	4445
16	1040	47	1466	78	4810
17	1046	48	1494	79	5241
18	1051	49	1524	80	5759
19	1058	50	1556	81	6392
20	1064	51	1589	82	7285
21	1071	52	1624	83	8205
22	1078	53	1662	84	9567
23	1086	54	1701	85	11474
24	1095	55	1743	86	14335
25	1103	56	1788	87	19107
26	1113	57	1836	88	28654
27	1122	58	1887	89	57299
28	1132	59	1942	90	*Infinite*
29	1143	60	2000		
30	1155	61	2063		

A

TABLE

OF

Meridional Parts,

For the Making, or Exact Conſtruction of the Meridian Line in a Mercator's Chart; and Solving the Caſes in *Mercator*'s *Sailing*.

Deg. of Lat.	The Minutes of each Degree.						Difference.
	0 m.	5 m.	10 m	15 m.	20 m.	25 m	
	The Meridional Parts.						
0	0	5	10	15	20	25	5
1	60	65	70	75	80	85	5
2	120	125	130	135	140	145	5
3	180	185	190	195	200	205	5
4	240	245	250	255	260	265	5
5	300	305	310	315	320	325	5
6	361	366	371	376	381	386	5
7	421	426	431	436	441	446	5
8	482	487	492	497	502	507	5
9	542	547	552	557	562	567	5
10	603	608	613	618	623	628	5
11	664	669	674	679	684	690	5
12	725	730	736	741	746	751	5
13	787	792	797	802	807	812	5
14	845	854	859	864	869	874	5
15	910	916	921	926	931	936	5
16	973	978	983	988	994	999	5
17	1035	1041	1046	1051	1056	1061	6
18	1098	1103	1109	1114	1119	1125	6
19	1161	1167	1172	1177	1183	1188	6
20	1225	1230	1236	1241	1246	1222	6
21	1289	1295	1300	1305	1311	1316	6
22	1354	1359	1364	1370	1375	1381	6
23	1419	1424	1429	1435	1440	1446	6
24	1484	1490	1495	1500	1506	1511	6
25	1550	1556	1561	1567	1572	1578	6
26	1616	1622	1628	1633	1639	1644	6
27	1684	1689	1695	1700	1706	1712	6
28	1751	1757	1762	1768	1774	1780	6
29	1819	1825	1831	1837	1842	1148	6

Deg. of Lat.	The Minutes of each Degree.						Difference.
	30 m.	35 m.	40 m.	45 m.	50 m.	55 m.	
	The Meridional Parts.						
0	30	35	40	45	50	55	5
1	90	95	100	105	110	115	5
2	150	155	160	165	170	175	5
3	210	215	220	225	230	235	5
4	270	275	280	285	290	295	5
5	330	335	341	346	351	356	5
6	391	396	401	406	411	416	5
7	451	456	461	466	471	476	5
8	512	517	522	527	532	537	5
9	573	578	583	588	593	598	5
10	634	639	644	649	654	659	5
11	695	700	705	710	715	720	5
12	756	761	766	771	776	781	5
13	818	823	828	833	838	843	5
14	879	885	890	895	900	905	5
15	942	947	952	957	962	967	5
16	1004	1009	1014	1020	1025	1030	5
17	1067	1072	1077	1082	1088	1093	6
18	1130	1135	1140	1146	1151	1156	6
19	1193	1199	1204	1209	1214	1220	6
20	1257	1262	1268	1273	1278	1284	6
21	1321	1327	1332	1338	1343	1348	6
22	1386	1392	1397	1402	1408	1413	6
23	1451	1457	1462	1468	1473	1479	6
24	1517	1522	1528	1533	1539	1544	6
25	1583	1589	1594	1600	1605	1611	6
26	1650	1656	1661	1667	1672	1678	6
27	1717	1723	1729	1734	1740	1745	6
28	1785	1791	1797	1802	1808	1814	6
29	1854	1860	1865	1871	1877	1883	6

Deg. of Lat.	The Minutes of each Degree.						Difference.
	0 m.	5 m.	10 m.	15 m.	20 m.	25 m.	
	The Meridional Parts.						
30	1888	1894	1900	1906	1912	1917	6
31	1958	1964	1970	1976	1981	1987	6
32	2028	2034	2040	2046	2052	2058	6
33	2100	2106	2111	2117	2123	2129	6
34	2171	2177	2183	2190	2196	2202	6
35	2244	2250	2256	2263	2269	2275	6
36	2318	2324	2330	2336	2343	2349	6
37	4393	2399	2405	2411	2418	2424	6
38	2468	2475	2481	2487	2494	2500	7
39	2544	2551	2558	2564	2571	2577	7
40	2622	2629	2636	2642	2649	2655	7
41	2702	2708	2715	2722	2728	2735	7
42	2782	2789	2795	2802	2809	2816	7
43	2863	2870	2877	2884	2891	2897	7
44	2946	2953	2960	2967	2974	2981	7
45	3030	3037	3044	3051	3058	3066	7
46	3116	3123	3130	3137	3145	3152	7
47	3203	3210	3217	3225	3232	3240	8
48	3292	3299	3307	3314	3322	3329	8
49	3382	3390	3397	3405	3413	3420	8
50	3475	3482	3490	3498	3506	3514	8
51	3569	3577	3585	3593	3601	3609	8
52	3665	3673	5682	3690	3698	3706	8
53	3764	3772	3781	3789	3797	3808	9
54	3865	3873	3882	3890	3899	3908	9
55	3968	3977	3986	3994	4003	4012	9
56	4074	4083	4092	4101	4110	4119	9
57	4183	4192	4201	4211	4220	4229	9
58	4295	4304	4314	4323	4333	4342	10
59	4409	4410	4429	4439	4448	4458	10

Deg. of Lat.	The Minutes of each Degree.						Difference.
	30 m.	35 m.	40 m.	45 m.	50 m.	55 m.	
	The Meridional Parts.						
30	1923	1929	1935	1941	1946	1952	6
31	1993	1999	2005	2011	2017	2022	6
32	2064	2070	2076	2082	2088	2094	6
33	2135	2141	2147	2153	2159	2165	6
34	2208	2214	2220	2226	2232	2238	6
35	2281	2287	2293	2300	2306	2312	6
36	2355	2361	2368	2374	2380	2386	6
37	2430	2437	2443	2449	2456	2462	6
38	2507	2513	2519	2526	2532	3539	7
39	2584	2590	2597	2603	2610	2616	7
40	2662	2669	2675	2682	2688	2695	7
41	2742	2748	2755	2762	2768	2775	7
42	2822	2829	2836	2843	2850	2836	7
43	2904	2911	2918	2925	2932	2939	7
44	2988	2995	3002	3009	3016	3023	7
45	3073	3080	3087	3094	3101	3108	7
46	3159	3166	3174	3181	3188	3195	7
47	3247	3254	3262	3269	3277	3284	8
48	3337	3344	3352	3359	3367	3374	8
49	3428	3436	3444	3451	3459	3467	8
50	3522	3529	3537	3545	3553	3561	8
51	3617	3625	3633	3641	3649	3657	8
52	3714	3723	3731	3739	3747	3756	8
53	3814	3823	3831	3839	3848	3856	9
54	3916	3925	3933	3942	3951	3989	9
55	4021	4030	4039	4047	4056	4065	9
56	4128	4137	4146	4155	4165	4174	9
57	4238	4248	4257	4266	4275	4285	9
58	4352	4361	4371	4380	4390	4400	10
59	4468	4478	4488	4498	4508	4518	10

Deg. of Lat	The Minutes of each Degree.						Difference.
	0 m.	5 m.	10 m.	15 m.	20 m.	25 m.	
	The Meridional Parts.						
60	4528	4538	4548	4558	4568	4578	10
61	4649	4660	4670	4681	4691	4702	11
62	4775	4786	4797	4807	4818	4829	11
63	4905	4916	4927	4938	4949	4960	11
64	5040	5051	5062	5074	5086	5099	12
65	5179	5191	5203	5215	5227	5237	12
66	5324	5336	5349	5361	5374	5386	13
67	5475	5487	5500	5513	5526	5539	13
68	5631	5645	5658	5672	5685	5699	14
69	5795	5809	5823	5837	5851	5865	14
70	5967	5981	5996	6011	6026	6041	15
71	6146	6162	6177	6193	6209	6225	16
72	6336	6352	6368	6384	6401	6417	16
73	6535	6552	6570	6587	6605	6622	17
74	6747	6765	6783	6801	6819	6839	18
75	6971	6991	7010	7030	7050	7070	20
76	7211	7232	7253	7274	7295	7316	21
77	7469	7491	7513	7536	7559	7582	23
78	7746	7770	7794	7819	7844	7869	25
79	8048	8074	8100	8127	8154	8181	27
80	8376	8406	8435	8465	8495	8525	30
81	8741	8774	8806	8839	8872	8905	33
82	9148	9184	9221	9258	9295	9333	37
83	9609	9650	9692	9735	9778	9821	42
84	10148	10188	10237	10287	10338	10389	50

The

Deg. of Lat.	The Minutes of each Degree.						Difference.
	30 m.	35 m.	40 m.	45 m.	50 m.	55 m.	
	The Meridional Parts.						
60	4588	4598	4609	4619	4629	4639	10
61	4712	4722	4733	4744	4754	4665	11
62	4840	4851	4862	4872	4883	4894	11
63	4972	4983	4995	5006	5017	5028	11
64	5100	5121	5132	5144	5156	5167	12
65	5251	5263	5275	5287	5309	5312	12
66	5399	5411	5424	5436	5449	5462	13
67	5552	5565	5578	5592	5605	5618	13
68	5712	5726	5739	5753	5767	5781	14
69	5880	5894	5909	5923	5938	5953	15
70	6056	6071	6086	6101	6116	6131	15
71	6240	6256	6272	6288	6304	6320	16
72	6434	6451	6468	6484	6501	6518	17
73	6640	6657	6675	6693	6711	6729	18
74	6857	6876	6895	6914	6933	6952	19
75	7090	7110	7130	7150	7170	7190	20
76	7337	7359	7381	7403	7425	7447	22
77	7605	7628	7651	7675	7698	7722	24
78	7894	7919	7944	7970	7996	8022	26
79	8208	8236	8264	8292	8320	8349	28
80	8555	8586	8617	8648	8979	8710	31
81	8939	8973	9007	9042	9077	9113	35
82	9371	9410	9449	9488	9528	9568	40
83	9864	9910	9953	10000	10046	10093	46
84	10441	10494	10547	10601	10656	10713	55

D.	1	2	3	4
5	1	2	3	4
6	1	2	3	5
7	1	3	4	6
8	2	3	5	6
9	2	4	5	7
10	2	4	6	8
11	2	4	7	9
12	2	5	7	10
13	3	5	8	10
14	3	6	8	11
15	3	6	9	12
16	3	6	10	13
17	3	7	10	14
18	4	7	11	14
19	4	8	12	15
20	4	8	13	16
21	4	8	13	17

D.	1	2	3	4
22	4	9	13	18
23	5	9	14	18
24	5	10	14	19
25	5	10	15	20
26	5	10	16	21
27	5	11	16	22
28	6	11	17	22
30	6	12	18	24
31	6	12	19	25
33	7	13	20	26
35	7	14	21	28
37	7	15	22	30
40	8	16	24	32
42	8	17	25	34
46	9	18	21	37
50	10	20	30	40
55	11	22	33	44

TABLE 14.

Lat. D. M.	Miles. Long.	Lat. D. M	Miles. Long.
18.11	57	63.15	27
25.50	54	66.25	24
31.47	51	69.31	21
36.52	48	72.32	18
41.25	45	75.31	15
45.34	42	78.28	12
49.27	39	81.22	9
53.08	36	84.16	6
56.38	33	87.08	3
60.00	30		

A Table

A Table shewing how many Miles do answer to a Degree of Longitude at every Degree of Latitude.

D. L.	Miles.	D. L.	Miles.	D. L.	Miles.	D. L.	Miles.
1	59.99	23	55.23	45	42.43	67	23.45
2	59.96	24	54.81	46	41.68	68	22.48
3	59.92	25	54.38	47	40.92	69	21.50
4	59.86	26	53.93	48	40.15	70	20.52
5	59.77	27	53.46	49	39.36	71	19.54
6	59.67	28	52.97	50	38.57	72	18.55
7	59.56	29	52.47	51	37.76	73	17.54
8	59.42	30	51.96	52	36.94	74	16.53
9	59.26	31	51.43	53	36.11	75	15.52
10	59.08	32	50.88	54	35.26	76	14.51
11	58.89	33	50.32	55	34.41	77	13.50
12	58.68	34	49.74	56	33.55	78	12.48
13	58.46	35	49.15	57	32.68	79	11.45
14	58.22	36	48.54	58	31.79	80	10.42
15	57.95	37	47.92	59	30.90	81	9.38
16	57.67	38	47.28	60	30. 0	82	8.35
17	57.37	39	46.62	61	29. 9	83	7.32
18	57.06	40	45.95	62	28.17	84	6.28
19	56.73	41	45.28	63	27.24	85	5.23
20	56.38	42	44.59	64	26.30	86	4.18
21	56.01	43	43.88	65	25.36	87	3.14
22	55.63	44	43.16	66	25.41	88	2.09
23	55.23	45	42 43	67	23.45	89	1.05

Difference Lat. on all Rumbs 60.

No. 16.

P.	Dist.	Dep.
1	60.1	3.0
2	60.3	6.0
3	60.6	8.8
I.	61.1	12.1
1	61.9	15.0
2	62.7	18.2
3	63.7	22.5
II.	64.9	24.8
1	66.4	28.4
2	68.0	32.1
3	70:0	36.1
III.	72.2	40.1
1	74.7	44.5
2	77.7	49.3
3	81.6	54 4
IV.	84.9	60.0
1	89.4	66.2
2	94.6	73.2
3	106.6	81.0
V.	108.0	89.8
1	120.0	100.2
2	127.0	113.0
3	140.0	127.0
VI.	157.0	144.0
1	178.0	168.1
2	207.8	198.0
3	247.0	240.2
VII	308.0	303.0
1	409.0	405.0
2	613.0	610.0
3	1221 0	1220. 0
VIII	Infinite.	

The Names of the Pieces of Ordnance.	Guns Weight.	Diameter of the Bore.		Diameter of the Shot.		Weight of the Shot.		Powder for Proof.		Powder for Service.		Paces Point-Blank.	Utmoſt Random.
	Lb.	I.	P.	I.	P.	lb.	oz	lb.	oz	l.	oz	Paces	Paces
Cannon Royal	8000	8	0	7	4	58	0	27	0	23	0	180	1800
Cannon 7.	6000	6	6	6	5	42	0	24	0	18	0	186	1800
Demi-Cannon	5200	6	9	6	7	32	0	20	0	15	0	180	1800
24 Pounders.	4800	5	6	5	6	24	0	17	0	11	0	180	1810
Culverin larg.	4500	5	3	5	1	18	0	14	0	10	0	184	1840
12 Pounders.	3000	4	4	4	2	10	6	10	5	8	0	178	1780
Demi-Culver.	2700	4	2	4	0	9	0	9	0	7	0	175	1750
Saker.	1500	3	5	3	4	5	4½	5	4½	4	0	160	1600
Minion.	1000	3	3	3	0	3	12	3	12	3	0	120	1200
Faucons.	750	2	6	2	4	2	8	2	5	1	8	120	1200
Rabanet.	300	1	4	1	2	0	8	0	18	0	12	120	1200
Baſe.	200	1	2	1	0	0	5	0	15	0	8	107	1070

NOTE, The Paces are accounted Five Foot each: Point-Blank is upon the Level: The Utmoſt Random, is when the Piece is Mounted to Forty five Degrees. The reſt of the TABLE is Obvious, and was inſerted here, to ſupply the Defect or Vacancy of this Page, and may be of good Uſe to the Sea-Gunner, &c.

Aſtronomical TABLES.

1. A Table of the Sun's Declination.

2. A Table of the Refractions of the Sun, Moon and Stars.

3. A Table of the Sun's Riſing and Setting; from the Equinoctial to 60 Degrees of Latitude North or South.

4. A Table ſhewing the Longeſt Day in any Latitude.

5. A Table of the Sun's Amplitudes Eaſt or Weſt, from the Equinoctial to 60 Degrees of Latitude, North or South.

6. A Table of the Sun's Right Aſcenſion in Time throughout the Year.

7. A Table of the Semi-Diurnal Arks, Seaſons for Obſerving, Right Aſcenſion and Declination of ſome Principal Fixed Stars.

First Year after Leap-Year.

Sun's Declination 1725. 1729, 1733, 1737, 1741.

Days	Jan. South.		Febr. South.		Mar. South		April. North.		May. North.		June. North.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21 ♑	39	13 ♒	39	3 ♓	17	8 ♈	4	18 ♉	09	23 ♊	11
2	21	28	13	19	2	58	9	5	18	24	23	15
3	21	18	12	59	2	29	9	26	18	39	23	18
4	21	07	12	38	2	05	9	47	18	53	23	21
5	20	56	12	17	1	42	10	09	19	07	23	23
6	20	44	11	56	1	18	10	30	19	21	23	25
7	20	32	11	35	0	54	10	51	19	34	23	27
8	20	19	11	14	0	31	11	12	19	47	23	28
9	20	16	10 ♓	53	0	07	11 ♉	32	20	00	23	29
	♒				North							
10	19	53	10	31	0 ♈	16	11	53	20	12	23	29
11	19	38	10	9	0	40	12	13	20 ♊	25	23 ♋	29
12	19	25	9	47	1	04	12	33	20	36	23	29
13	19	11	9	25	1	27	12	53	20	48	23	28
14	18	56	9	03	1	51	13	13	20	59	23	27
15	18	41	8	40	2	14	13	32	21	09	23	25
16	18	26	8	18	2	38	13	51	21	19	23	23
17	18	10	7	55	3	01	14	10	21	29	23	20
18	17	54	7	32	3	25	14	29	21	39	23	17
19	17	38	7	10	3	48	14	47	21	48	23	14
20	17	21	6	47	4	11	15	06	21	57	23	10
21	17	04	6	24	4	34	15	24	22	05	23	06
22	16	47	6	01	4	57	15	42	22	13	23	01
23	16	29	5	37	5	20	15	59	22	21	22	56
24	16	12	5	14	5	43	16	16	22	28	22	51
25	15	53	4	51	6	6	16	33	22	35	22	45
26	15	35	4	27	6	29	16	50	22	41	22	39
27	15	16	4	04	6	51	17	06	22	47	22	32
28	14	57	3	40	7	14	17	23	22	53	22	25
29	14	38			7	36	17	38	22	58	22	18
30	14	19			7	58	17	54	23	03	22	10
31	13	59			8	21			23	07		

First

First Year after Leap-Year.

Sun's Declination 1725, 1729, 1733, 1737, 1741.

Days.	July. North.		August North.		Sept. North		Octob. South.		Nov. South.		Dec. South.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	22 ♋	02	15 ♌	02	4 ♍	12	7 ♎	25	17 ♏	46	23 ♐	08
2	21	53	14	44	3	49	7	48	18	02	23	12
3	21	44	14	25	3	26	8	10	18	18	23	16
4	21	35	13	07	3	03	8	33	18	33	23	20
5	21	25	13	48	2	40	8	55	18	48	23	22
6	21	15	13	29	2	16	9	17	19	03	23	24
7	21	05	13	09	1	53	9	39	19	18	24	26
8	20	54	12	50	1	30	10	01	19	32	23	28
9	20	43	12	30	1	06	10	23	19	46	23	29
10	20	43	12	10	0	43	10	44	19	59	23 ♑	29
11	20 ♌	20	11	50	0	19	11	06	20	12	23	29
12	20	08	11	50	0	04	11	27	20 ♐	25	23	22
13	19	56	11 ♍	10	South	27	11 ♏	48	20	37	23	27
14	19	44	10	48	0 ♎	51	12	09	20	49	23	26
15	19	30	10	28	1	14	12	29	21	01	23	24
16	19	17	10	17	1	38	12	50	21	12	23	22
17	19	04	9	43	2	01	13	10	21	22	23	19
18	18	49	9	24	2	25	13	30	21	33	23	16
19	18	34	9	03	2	48	13	49	21	43	23	12
20	18	20	8	41	3	12	14	10	21	52	23	08
21	18	05	8	19	3	36	14	29	22	01	23	03
22	17	50	7	57	3	58	14	48	22	10	22	58
23	17	34	7	35	4	22	15	07	22	18	22	52
24	17	18	7	13	4	45	15	26	22	26	22	46
25	17	02	6	51	5	08	15	44	22	34	22	39
26	16	46	6	28	5	31	16	03	22	41	22	32
27	16	29	6	06	5	54	16	20	22	47	22	25
28	16	12	5	43	6	17	16	38	22	53	22	17
29	15	55	5	21	6	40	16	55	22	58	22	09
30	15	38	4	58	7	03	17	13	23	03	22	00
31	15	20	4	35			17	29			21	51

Second

Second Year after Leap-Year.

Sun's Declination 1726, 1730, 1734, 1738, 1742.

Days.	Jan. Sonth.		Febr. South.		Mar. South.		April. North.		May. North.		June. North.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21	41	13	44	3	22	8	37	18	06	23	10
2	21	31	13	24	2	59	8	59	18	21	23	14
3	21	21	13	04	2	35	9	21	18	35	23	17
4	21	10	12	43	2	11	9	42	18	50	23	20
5	20	59	12	22	1	48	10	03	19	04	23	23
6	20	47	12	01	1	24	10	25	19	18	23	25
7	20	35	11	40	1	00	10	46	19	31	23	26
8	20	22	11	19	0	37	11	07	19	44	23	28
9	20	10	10	58	0	13	11	27	19	57	23	29
10	19	56	10	36	Nor	10	11	48	20	10	23	29
11	19	43	10	14	0	34	12	08	20	22	23	29
12	19	29	9	52	0	58	12	28	20	33	23	29
13	19	15	9	32	P	21	12	48	20	45	23	28
14	19	00	9	08	1	45	13	08	20	56	23	27
15	18	45	8	46	2	08	13	27	21	07	23	25
16	18	30	8	23	2	32	13	47	21	17	23	23
17	18	24	8	01	2	55	14	06	21	27	23	21
18	17	58	7	38	3	18	14	24	21	36	23	18
19	17	42	7	15	3	42	14	43	21	45	23	14
20	17	25	6	52	4	05	15	01	21	54	23	11
21	17	08	6	29	4	29	15	19	22	03	23	07
22	16	51	6	06	4	52	15	37	22	11	23	02
23	16	34	5	43	5	15	15	55	22	19	22	57
24	16	16	5	20	5	38	16	12	22	26	22	52
25	15	58	4	57	6	01	16	19	22	33	22	46
26	15	39	4	33	6	23	16	46	22	40	22	40
27	15	21	4	09	6	46	17	02	22	46	22	34
28	15	02	3	46	7	08	17	19	22	51	22	27
29	14	43			7	31	17	35	22	57	22	20
30	14	23			7	53	17	50	23	02	22	12
31	14	04			8	15			23	06		

Second

Second Year after Leap-Year.

Sun's Declination 1728, 1730, 1734, 1738, 1742.

Days.	July. North.		Auguſt. North.		Sept. North		Octob. South.		Nov. South.		Dec. South.	
	D.	M.	D.	M	D.	M.	D.	M.	D.	M.	D.	M.
1	22	04	15	06	4	18	7	20	17	42	23	07
2	21	54	14	48	3	55	7	42	17	58	23	11
3	21	46	14	30	3	32	8	05	18	14	23	15
4	21	37	14	11	3	08	8	27	18	29	23	19
5	21	28	13	52	2	45	8	50	18	45	23	22
6	21	18	13	33	2	22	9	12	18	59	23	24
7	21	08	13	14	1	59	9	34	19	14	23	26
8	20	57	12	54	1	35	9	56	19	28	23	28
9	20	46	12	35	1	12	10	17	19	42	23	28
10	20	35	12	15	0	48	10	40	19	56	23	29
11	20	23	11	55	0	25	11	00	20	09	23	29
12	20	11	11	35	0	02	11	22	20	22	23	29
13	19	59	11	14	Sou	22	11	43	20	34	23	28
14	19	46	10	53	0	45	12	03	20	46	23	27
15	19	33	10	33	1	09	12	24	20	58	23	25
16	19	20	10	12	1	32	12	45	21	09	23	22
17	19	06	9	51	1	56	13	05	21	20	23	19
18	18	52	9	29	2	19	13	25	21	30	23	16
19	18	38	9	08	2	42	13	45	21	40	23	12
20	18	23	8	46	3	06	14	05	21	50	23	09
21	18	08	8	25	3	29	14	24	21	59	23	04
22	17	53	8	03	3	53	14	44	22	08	22	59
23	17	38	7	41	4	16	15	03	22	16	22	53
24	17	22	7	19	4	39	15	21	22	24	22	47
25	17	06	6	56	5	02	15	40	22	32	22	41
26	16	50	6	34	5	25	15	58	22	39	22	34
27	16	33	6	12	5	48	16	16	22	45	22	27
28	16	16	5	49	6	11	16	34	22	52	22	19
29	15	59	5	26	6	34	16	51	22	57	22	11
30	15	42	5	04	6	57	17	08	23	02	22	02
31	15	24	4	41			17	25			21	53

Third Year after Leap-Year.

Sun's Declination 1727, 1731, 1735, 1739, 1743.

Days.	Jan. South.		Febr. South.		Mar. South		April. North.		May. North.		June. North.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21	43	13	49	3	28	8	32	18	02	23	09
2	21	33	13	29	3	04	8	54	18	17	23	13
3	21	23	13	09	2	41	9	15	18	32	23	17
4	21	12	12	48	2	17	9	37	18	46	23	20
5	21	01	12	27	1	54	9	58	19	01	23	22
6	20	50	12	06	1	30	10	20	19	14	23	24
7	20	38	11	46	1	06	10	41	19	28	23	26
8	20	25	11	24	0	43	11	02	19	41	23	27
9	20	13	11	03	0	19	11	22	19	54	23	28
10	20	00	10	41	Nor	05	11	43	20	06	23	29
11	19	46	10	20	0	28	12	03	20	18	23	29
12	19	32	9	58	0	52	12	23	20	30	23	29
13	19	18	9	36	1	16	12	43	20	42	23	28
14	19	04	9	14	1	39	13	03	20	53	23	27
15	18	49	8	51	2	03	13	23	21	04	23	25
16	18	33	8	29	2	26	13	42	21	14	23	23
17	18	18	8	06	2	50	14	01	21	24	23	21
18	18	02	7	44	3	13	14	20	21	34	23	18
19	17	46	7	21	3	36	14	39	21	43	23	15
20	17	29	6	58	4	00	14	57	21	52	23	12
21	17	13	6	35	4	23	15	15	22	01	23	08
22	16	55	6	12	4	46	15	33	22	09	23	03
23	16	38	5	48	5	09	15	51	22	17	22	58
24	16	20	5	25	5	32	16	08	22	24	22	53
25	16	02	5	02	5	55	16	25	22	31	22	48
26	15	44	4	39	6	18	16	42	22	38	22	42
27	15	25	4	15	6	40	16	58	22	44	22	35
28	15	07	3	52	7	03	17	15	22	50	22	28
29	14	48			7	25	17	31	22	55	22	21
30	14	28			7	48	17	46	23	00	22	14
31	14	09			8	10			23	05		

Third Year after Leap-Year.

Sun's Declination 1727, 1731, 1735, 1739, 1743.

Days.	July. North.		August North.		Sept. North		Octob. South.		Nov. South.		Dec. South.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	22	05	15	11	4	23	7	14	17	38	23	06
2	21	57	14	53	4	00	7	37	17	54	23	10
3	21	49	14	34	3	37	8	00	18	10	23	14
4	21	40	14	16	3	14	8	22	18	26	23	18
5	21	30	13	57	2	51	8	44	18	41	23	21
6	21	20	13	38	2	28	9	06	18	56	23	23
7	21	10	13	19	2	04	9	28	19	11	23	25
8	21	00	12	59	1	41	9	50	19	25	23	27
9	20	49	12	49	1	18	10	12	19	39	23	28
10	20	38	12	20	0	54	10	34	19	52	23	29
11	20	26	12	00	0	31	10	55	20	06	23	29
12	20	14	11	40	0	07	11	17	20	19	23	29
13	20	02	11	19	Sou	16	11	38	20	31	23	28
14	19	49	10	59	0	39	11	59	20	43	23	27
15	19	36	10	38	1	03	12	19	20	55	23	25
16	19	03	10	17	1	26	12	40	21	06	23	23
17	19	09	9	56	1	50	13	00	21	17	23	20
18	18	57	9	35	2	13	13	21	21	28	23	17
19	18	41	9	13	2	37	13	40	21	38	23	14
20	18	27	8	52	3	00	14	00	21	48	23	10
21	18	12	8	30	3	24	14	20	21	57	23	05
22	17	57	8	08	3	47	14	39	22	06	23	00
23	17	42	7	46	4	10	14	58	22	14	22	55
24	17	26	7	24	4	33	15	17	22	22	22	49
25	17	10	7	02	4	57	15	35	22	30	22	43
26	16	54	6	40	5	20	15	54	22	37	22	36
27	16	37	6	17	5	43	16	12	22	44	22	28
28	16	20	5	55	6	06	16	29	22	50	22	21
29	16	03	5	32	6	29	16	41	22	56	22	13
30	15	46	5	09	6	52	17	04	23	01	22	04
31	15	28	4	46			17	41			21	55

Leap-Year.

Sun's Declination 1724, 1728, 1732, 1736, 1740.

Days.	Jan.		Febr.		Mar.		April.		May.		June.	
	Sonth.		South.		South.		North.		North.		North.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	21	46	13	54	3	10	8	48	18	13	23	12
2	21	36	13	34	2	47	9	10	18	28	23	16
3	21	26	13	14	2	23	9	32	18	43	23	19
4	21	15	12	53	1	59	9	53	18	57	23	22
5	21	04	12	33	1	36	10	14	19	11	23	24
6	20	53	12	12	1	12	10	35	19	24	23	26
7	20	41	11	51	0	48	10	56	19	38	23	27
8	20	29	11	30	0	25	11	17	19	51	23	28
9	20	16	11	08	0	01	11	38	20	03	23	29
10	20	03	10	47	Nor	23	11	48	20	16	23	29
11	19	50	10	25	0	46	12	19	20	28	23	29
12	19	36	10	03	1	10	12	38	20	39	23	28
13	19	22	9	41	1	34	12	58	20	50	23	27
14	19	07	9	19	1	57	13	18	21	01	23	26
15	18	52	9	57	2	21	13	37	21	12	23	24
16	18	37	8	37	2	44	13	56	21	22	23	22
17	18	21	8	12	3	08	14	15	21	32	23	19
18	18	06	7	49	3	31	14	34	21	41	23	16
19	17	50	7	26	3	54	14	52	21	50	23	12
20	17	34	7	03	4	17	15	11	21	59	23	09
21	17	17	6	40	4	41	15	28	22	07	23	04
22	17	00	6	17	5	04	15	46	22	15	23	59
23	16	42	5	54	5	27	16	04	22	23	22	54
24	16	25	5	31	5	49	16	21	22	30	22	49
25	16	07	5	08	6	12	16	38	22	36	22	43
26	15	48	4	44	6	35	16	54	22	43	22	37
27	15	30	4	21	6	57	17	11	22	49	22	30
28	15	11	3	57	7	20	17	27	22	54	22	23
29	14	52	3	34	7	42	17	43	22	58	22	16
30	14	33			8	04	17	58	23	04	22	08
31	14	13			8	26			23	08		

Leap-Year,

Sun's Declination 1724. 1728, 1732, 1736, 1740.

Days.	July. North. D.	M.	Aug. North. D.	M.	Sept. North D.	M.	Octob. South. D.	M.	Nov. South. D.	M.	Dec. South. D.	M.
1	21	59	14	57	4	06	7	32	17	50	23	09
2	21	51	14	39	3	43	7	54	18	06	23	13
3	21	42	14	20	3	20	8	14	18	22	23	17
4	21	32	14	01	2	57	8	39	18	37	23	20
5	21	22	13	42	2	33	9	01	18	52	23	23
6	21	13	13	23	2	10	9	23	19	07	23	25
7	21	02	13	04	1	47	9	45	19	22	23	26
8	20	51	12	44	1	23	10	07	19	36	23	28
9	20	40	12	24	1	00	10	29	19	49	23	29
10	20	29	12	04	0	36	10	50	20	02	23	29
11	20	17	11	44	0	13	11	11	20	15	23	29
12	20	05	11	24	Sou	10	11	33	20	28	23	28
13	19	53	11	04	0	34	11	54	20	40	23	27
14	19	39	10	43	0	57	12	14	20	52	23	26
15	19	26	10	22	1	21	12	35	21	03	23	24
16	19	13	10	01	1	44	12	55	21	15	23	21
17	18	59	9	40	2	08	13	16	21	25	23	18
18	18	45	9	18	2	31	13	36	21	35	23	15
19	18	30	8	57	2	55	13	55	21	45	23	11
20	18	16	8	35	3	18	14	15	21	54	23	06
21	18	01	8	13	3	41	14	34	22	03	23	01
22	17	45	7	52	4	05	14	54	22	12	22	56
23	17	30	7	29	4	28	15	12	22	20	22	50
24	17	14	7	07	4	51	15	31	22	28	22	44
25	16	58	6	45	5	14	15	49	22	35	22	37
26	16	41	6	23	5	37	16	07	22	42	22	30
27	16	24	6	00	6	00	16	25	22	48	22	23
28	16	07	5	37	6	23	16	43	22	54	22	15
29	15	50	5	15	6	46	17	00	23	00	22	06
30	15	33	4	52	7	09	17	34	23	05	21	57
31	15	15	4	29							21	48

A Table to Reduce the Sun's Declination to any other Meridian than London.

Deg. of Lon.	15		30		45		60		75		90		105		120		135		150		165		180	
M.	M		M		M		M		M		M		M		M		M		M		M		M	
2	0		0		0		0		0		0		1		1		1		1		1		1	
3	0		0		0		0		1		1		1		1		1		1		1		1	
4	0		0		1		1		1		1		1		1		1		2		2		2	
5	0		0		1		1		1		1		1		2		2		2		2		2	
6	0		0		1		1		1		1		2		2		2		2		3		3	
7	0		0		1		1		1		2		2		3		3		3		3		3	
8	0		0		1		1		1		2		2		3		3		3		4		4	
9	0		0		1		1		2		2		3		3		3		4		4		4	
10	0		0		1		1		2		2		3		3		4		4		5		5	
11	0		0		1		1		2		2		3		4		4		5		5		5	
12	0		0		1		1		2		2		3		4		4		5		5		6	
13	0		1		1		2		2		3		3		4		5		5		6		6	
14	1		1		2		2		3		3		4		5		5		6		6		7	
15	1		1		2		2		3		4		4		5		6		6		7		7	
16	1		1		2		3		3		4		5		5		6		7		7		8	
17	1		1		2		3		4		4		5		6		6		7		8		8	
18	1		1		2		3		4		4		5		6		7		7		8		9	
19	1		2		2		3		4		5		6		6		7		8		9		9	
20	1		2		2		3		4		5		6		6		7		8		9		10	
21	1		2		3		3		4		5		6		6		8		9		10		10	
22	1		2		3		4		5		5		7		7		8		9		10		11	
23	1		2		3		4		5		6		7		7		9		10		11		11	
24	1		2		3		4		5		6		7		7		9		10		11		12	

Daily Difference of Declination.

No. 19. *A Table of Refractions of ☉, ☽ and ✶s.*

Alt	☉'s Ref.	☽s Ref	✶s Ref
D.	M.	M.	M.
0	34	33	30
1	26	25	21
2	20	20	15
3	17	17	12
4	15	15	11
5	14	14	10
6	13	13	9
7	12	13	8
8	11	12	7
9	10	11	6
10	10	11	5
11	9	10	5
12	9	9	4
13	8	9	4
14	8	8	3
15	7	8	3
16	7	7	2
17	7	7	2
18	6	6	1
19	5	6	0

East { Long. with Decl. { Incr. / Decr. } Subtr. but Decl. { Decr. / Incr. } Add.
West

No. 20.

A TABLE OF THE SUN's Rising and Setting, from the EQUINOCTIAL to the Latitude of 60 Degrees North or South.

A Table shewing the Time of Sun-setting, when the Sun hath North-Declination; and the Time of Sun-rising, when the Sun hath South-Declination.

Sun's Declinat. Degrees of Declination.	The Degrees of Latitude.											
	1		2		3		4		5		6	
	H.	M	H.	M	H.	M	H.	M	H.	M	H.	M
0	6	0	6	0	6	0	6	0	6	0	6	0
1	6	0	6	0	6	0	6	0	6	0	6	0
2	6	0	6	0	6	0	6	0	6	1	6	1
3	6	0	6	0	6	1	6	1	6	1	6	1
4	6	0	6	0	6	1	6	1	6	1	6	2
5	6	0	6	0	6	1	6	1	6	2	6	2
6	6	0	6	1	6	1	6	2	6	2	6	3
7	6	0	6	1	6	1	6	2	6	2	6	3
8	6	0	6	1	6	2	6	2	6	3	6	3
9	6	1	6	1	6	2	6	3	6	3	6	4
10	6	1	6	1	6	2	6	3	6	4	6	4
11	6	1	6	1	6	2	6	3	6	4	6	5
12	6	1	6	2	6	2	6	3	6	4	6	6
13	6	1	6	2	6	3	6	4	6	5	6	6
14	6	1	6	2	6	3	6	4	6	5	6	6
15	6	1	6	2	6	3	6	4	6	5	6	6
16	6	1	6	2	6	3	6	5	6	6	6	7
17	6	1	6	2	6	4	6	5	6	6	6	7
18	6	1	6	3	6	4	6	5	6	7	6	8
19	6	1	6	3	6	4	6	5	6	7	6	8
20	6	1	6	3	6	4	6	6	6	7	6	9
21	6	2	6	3	6	5	6	6	6	8	6	9
22	6	2	6	3	6	5	6	6	6	8	6	10
23	6	2	6	3	6	5	6	7	6	9	6	10
23,29	6	2	6	4	6	5	6	7	6	9	6	11

Double the Time of Sun's {Setting / Rising} gives the Length of the {Day / Night.}

Sun's Declinat.	The Degrees of Latitude. 7	8	9	10	11	12
	H.M	H.M	H.M	H.M	H.M	H.M
0	6 0	6 0	6 0	6 0	6 0	6 0
1	6 0	6 0	6 1	6 1	6 1	6 1
2	6 1	6 1	6 1	6 1	6 2	6 2
3	6 1	6 2	6 2	6 2	6 2	6 3
4	6 2	6 2	6 2	6 3	6 3	6 3
5	6 2	6 3	6 3	6 4	6 4	6 4
6	6 3	6 3	6 4	6 4	6 5	6 5
7	6 3	6 4	6 4	6 5	6 5	6 6
8	6 4	6 4	6 5	6 6	6 6	6 7
9	6 4	6 5	6 6	6 6	6 7	6 8
10	6 5	6 6	6 6	6 7	6 8	6 9
11	6 5	6 6	6 7	6 8	6 9	6 9
12	6 6	6 7	6 8	6 9	6 9	6 10
13	6 6	6 7	6 8	6 9	6 10	6 11
14	6 7	6 8	6 9	6 10	6 11	6 12
15	6 8	6 9	6 10	6 11	6 12	6 13
16	6 8	6 9	6 10	6 12	6 13	6 14
17	6 9	6 10	6 11	6 12	6 14	6 15
18	6 9	6 10	6 12	6 13	6 14	6 16
19	6 10	6 11	6 13	6 14	6 15	6 17
20	6 10	6 12	6 14	6 15	6 16	6 18
21	6 11	6 12	6 14	6 16	6 17	6 19
22	6 11	6 13	6 15	6 16	6 18	6 20
23	6 12	6 14	6 15	6 17	6 19	6 21
23.29	6 12	6 14	6 16	6 18	6 19	6 22

Degrees of Declination.

A Table shewing the Time of Sun-setting, when the Sun hath North Declination; and the Time of Sun-rising when the Sun hath South Declination.

Sun's Declinat.	The Degrees of Latitude.											
	13		14		15		16		17		18	
Degrees of Declination.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
0	6.	00	6.	00	6.	00	6.	00	6.	00	6.	00
1	6.	01	6.	01	6.	01	6.	01	6.	01	6.	01
2	6.	02	6.	02	6.	02	6.	02	6.	02	6.	02
3	6.	03	6.	03	6.	03	6.	03	6.	04	6.	04
4	6.	04	6.	04	6.	04	6.	05	6.	05	6.	05
5	6.	05	6.	05	6.	05	6.	06	6.	06	6.	06
6	6.	06	6.	06	6.	06	6.	07	6.	07	6.	08
7	6.	07	6.	08	6.	07	6.	08	6.	09	6.	09
8	6.	08	6.	09	6.	08	6.	09	6.	10	6.	10
9	6.	09	6.	10	6.	09	6.	10	6.	11	6.	12
10	6.	10	6.	11	6.	11	6.	12	6.	12	6.	13
11	6.	11	6.	12	6.	12	6.	13	6.	13	6.	14
12	6.	12	6.	13	6.	13	6.	14	6.	15	6.	16
13	6.	13	6.	14	6.	14	6.	15	6.	16	6.	17
14	6.	14	6.	15	6.	15	6.	16	6.	17	6.	19
15	6.	15	6.	16	6.	16	6.	18	6.	19	6.	20
16	6.	16	6.	17	6.	17	6.	19	6.	20	6.	21
17	6.	17	6.	18	6.	18	6.	20	6.	21	6.	23
18	6.	18	6.	19	6.	19	6.	21	6.	23	6.	24
19	6.	19	6.	20	6.	21	6.	23	6.	24	6.	29
20	6.	20	6.	21	6.	22	6.	24	6.	25	6.	27
21	6.	21	6.	22	6.	22	6.	25	6.	27	6.	29
22	6.	22	6.	23	6.	24	6.	27	6.	28	6.	30
23	6.	23	6.	24	6.	25	6.	28	6.	30	6.	32
23.29	6.	24	6.	25	6.	26	6.	29	6.	31	6.	33

Double

Double the Time of Sun's { Setting, Rising, } gives the Length of the { Day. Night.

Sun's Declinat.	The Degrees of Latitude.											
	19		20		21		22		23		24	
Degrees of Declination.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
0	6.	00	6.	00	6.	00	6.	00	6.	00	6.	00
1	6.	01	6.	01	6.	01	6.	02	6.	02	6.	02
2	6.	03	6.	03	6.	03	6.	03	6.	03	6.	03
3	6.	04	6.	04	6.	05	6.	05	6.	05	6.	05
4	6.	05	6.	06	6.	06	6.	06	6.	07	6.	07
5	6.	07	6.	07	6.	08	6.	08	6.	09	6.	09
6	6.	08	6.	09	6.	09	6.	10	6.	10	6.	11
7	6.	10	6.	10	6.	11	6.	11	6.	12	6.	13
8	6.	11	6.	12	6.	12	6.	13	6.	14	6.	14
9	6.	13	6.	13	6.	14	6.	15	6.	15	6.	16
10	6.	14	6.	15	6.	16	6.	16	6.	17	6.	18
11	6.	15	6.	16	6.	17	6.	18	6.	19	6.	20
12	6.	17	6.	18	6.	19	6.	20	6.	21	6.	22
13	6.	18	6.	19	6.	20	6.	21	6.	23	6.	24
14	6.	20	6.	21	6.	22	6.	23	6.	24	6.	25
15	6.	21	6.	22	6.	24	6.	25	6.	26	6.	27
16	6.	23	6.	24	6.	25	6.	27	6.	28	6.	29
17	6.	24	6.	25	6.	27	6.	28	6.	30	6.	31
18	6.	26	6.	27	6.	29	6.	30	6.	32	6.	33
19	6.	27	6.	29	6.	30	6.	32	6.	34	6.	35
20	6.	28	6.	30	6.	32	6.	30	6.	36	6.	37
21	6.	30	6.	32	6.	34	6.	36	6.	37	6.	39
22	6.	31	6.	33	6.	35	6.	37	6.	39	6.	41
23	6.	33	6.	35	6.	37	6.	39	6.	41	6.	43
23.29	6.	34	6.	36	6.	39	6.	40	6.	43	6.	45

A Table shewing the Time of Sun-setting, when the Sun hath North-Declination; and the Time of Sun-rising, when the Sun hath South-Declination.

Sun's Declinat.	The Degrees of Latitude.											
	25		26		27		28		29		30	
Degrees of Declination.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
0	6.	00	6.	00	6.	00	6.	00	6.	00	6.	00
1	6.	02	6.	02	6.	02	6.	02	6.	02	6.	02
2	6.	04	6.	04	6.	04	6.	04	6.	04	6.	05
3	6.	06	6.	06	6.	06	6.	06	6.	07	6.	07
4	6.	07	6.	08	6.	08	6.	09	6.	09	6.	09
5	6.	09	6.	10	6.	10	6.	11	6.	11	6.	12
6	6.	11	6.	12	6.	12	6.	13	6.	13	6.	14
7	6.	13	6.	14	6.	14	6.	15	6.	16	6.	16
8	6.	15	6.	16	6.	16	6.	17	6.	18	6.	19
9	6.	17	6.	18	6.	19	6.	19	6.	20	6.	21
10	6.	19	6.	20	6.	21	6.	22	6.	23	6.	23
11	6.	21	6.	22	6.	23	6.	24	6.	25	6.	26
12	6.	23	6.	24	6.	25	6.	26	6.	27	6.	28
13	6.	25	6.	26	6.	27	6.	28	6.	29	6.	31
14	6.	27	6.	28	6.	29	6.	30	6.	32	6.	33
15	6.	29	6.	30	6.	31	6.	33	6.	34	6.	36
16	6.	31	6.	32	6.	34	6.	35	6.	37	6.	38
17	6.	33	6.	34	6.	36	6.	37	6.	39	6.	41
18	6.	35	6.	36	6.	38	6.	40	6.	42	6.	43
19	6.	37	6.	39	6.	40	6.	42	6.	44	6.	46
20	6.	39	6.	41	6.	43	6.	45	6.	47	6.	48
21	6.	41	6.	43	6.	45	6.	47	6.	49	6.	51
22	6.	43	6.	45	6.	48	6.	50	6.	52	6.	54
23	6.	46	6.	48	6.	50	6.	52	6.	54	6.	57
23.29	6.	47	6.	49	6.	51	6.	53	6.	56	6.	59

Double the Time of Sun's { Setting / Rising } gives the Length of the { Day. / Night.

Sun's Declinat. Degrees of Declination.	The Degrees of Latitude.											
	31		32		33		34		35		36	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
0	6.	00	6.	00	6.	00	6.	00	6.	00	6.	00
1	6.	02	6.	02	6.	03	6.	03	6.	03	6.	03
2	6.	05	6.	05	6.	05	6.	05	6.	06	6.	06
3	6.	07	6.	08	6.	08	6.	08	6.	08	6.	09
4	6.	10	6.	10	6.	11	6.	11	6.	11	6.	12
5	6.	12	6.	13	6.	13	6.	14	6.	14	6.	15
6	6.	15	6.	15	6.	16	6.	16	6.	17	6.	18
7	6.	17	6.	18	6.	18	6.	19	6.	20	6.	20
8	6.	19	6.	20	6.	21	6.	22	6.	23	6.	23
9	6.	22	6.	23	6.	24	6.	25	6.	25	6.	26
10	6.	24	6.	25	6.	26	6.	27	6.	28	6.	29
11	6.	27	6.	28	6.	29	6.	30	6.	31	6.	32
12	6.	29	6.	31	6.	32	6.	33	6.	34	6.	36
13	6.	32	6.	33	6.	34	6.	36	6.	37	6.	39
14	6.	34	6.	36	6.	37	6.	39	6.	40	6.	42
15	6.	37	6.	39	6.	40	6.	42	6.	43	6.	45
16	6.	40	6.	41	6.	43	6.	45	6.	46	6.	48
17	6.	42	6.	44	6.	46	6.	48	6.	49	6.	51
18	6.	45	6.	47	6.	49	6.	51	6.	53	6.	55
19	6.	48	6.	50	6.	52	6.	54	6.	36	6.	58
20	6.	51	6.	53	6.	55	6.	57	6.	59	7.	01
21	6.	53	6.	56	6.	58	7.	00	7.	02	7.	05
22	6.	56	6.	58	7.	01	7.	03	7.	06	7.	08
23	6.	59	7.	01	7.	04	7.	06	7.	09	7.	12
23,29	7.	01	7.	03	7.	06	7.	08	7.	11	7.	14

A Table shewing the Time of Sun-setting, when the Sun hath North Declination; and the Time of Sun-rising, when the Sun hath South Declination.

Sun's Declinat. Degrees of Declination.	The Degrees of Latitude.											
	37		38		39		40		41		42	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
0	6	00	6	00	6	00	6	00	6	00	6	00
1	6	03	6	03	6	03	6	03	6	03	6	04
2	6	06	6	06	6	06	6	07	6	07	6	07
3	6	09	6	09	6	10	6	10	6	10	6	11
4	6	12	6	13	6	13	6	13	6	14	6	14
5	6	15	6	16	6	16	6	17	6	17	6	18
6	6	28	6	19	6	20	6	21	6	21	6	22
7	6	21	6	22	6	23	6	25	6	25	6	25
8	6	24	6	25	6	26	6	28	6	29	6	29
9	6	27	6	28	6	29	6	31	6	32	6	33
10	6	31	6	32	6	33	6	34	6	35	6	37
11	6	34	6	35	6	36	6	38	6	39	6	40
12	6	37	6	38	6	40	6	41	6	43	6	44
13	6	40	6	42	6	43	6	45	6	46	6	48
14	6	43	6	45	6	47	6	48	6	50	6	52
15	6	47	6	48	6	50	6	52	6	54	6	56
16	6	50	6	52	6	54	6	56	6	58	7	00
17	6	53	6	55	6	57	7	00	7	02	7	04
18	6	57	6	59	7	01	7	03	7	06	7	08
19	7	00	7	02	7	05	7	07	7	10	7	12
20	7	04	7	06	7	09	7	11	7	14	7	17
21	7	07	7	10	7	12	7	15	7	18	7	21
22	7	11	7	14	7	16	7	19	7	22	7	25
23	7	15	7	17	7	20	7	23	7	27	7	30
23.29	7	17	7	19	7	22	7	16	7	29	7	32

Double

Double the Time of Sun's { Setting, / Rising, } gives the Length of the { Day. / Night,

Sun's Declinat. Degrees of Declination.	The Degrees of Latitude.											
	43		44		45		46		47		48	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
0	6	00	6	00	6	00	6	00	6	00	6	00
1	6	04	6	04	6	04	6	04	6	04	6	04
2	6	07	6	08	6	08	6	08	6	09	6	09
3	6	11	6	12	6	12	6	12	6	13	6	13
4	6	15	6	15	6	16	6	17	6	17	6	18
5	6	19	6	19	6	20	6	21	6	22	6	22
6	6	22	6	23	6	24	6	25	6	26	6	27
7	6	26	6	27	6	28	6	29	6	30	6	31
8	6	30	6	31	6	32	6	33	6	35	6	36
9	6	34	6	35	6	36	6	38	6	39	6	41
10	6	38	6	39	6	41	6	43	6	44	6	45
11	6	42	6	43	6	45	6	46	6	48	6	50
12	6	46	6	47	6	49	6	51	6	53	6	55
13	6	50	6	52	6	53	6	55	6	57	6	59
14	6	54	6	56	6	58	7	00	7	02	7	04
15	6	58	7	00	7	02	7	04	7	07	7	09
16	7	02	7	04	7	07	7	09	7	12	7	14
17	7	06	7	09	7	11	7	14	7	17	7	19
18	7	11	7	13	7	16	7	19	7	22	7	25
19	7	15	7	18	7	21	7	24	7	27	7	30
20	7	19	7	22	7	25	7	29	7	32	7	35
21	7	24	7	27	7	30	7	34	7	37	7	41
22	7	28	7	31	7	35	7	39	7	43	7	47
23	7	33	7	37	7	40	7	44	7	48	7	53
23.29	7	36	7	39	7	43	7	47	7	51	7	56

A Table shewing the Time of Sun-setting, when the Sun hath North-Declination; and the Time of Sun-rising, when the Sun hath South-Declination.

Declinat. Sun's	The Degrees of Latitude.					
	49	50	51	52	53	54
Degrees of Declination.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
0	6 00	6 00	6 00	6 00	6 00	6 00
1	6 05	6 05	6 05	6 05	6 05	6 06
2	6 09	6 10	6 10	6 10	6 11	6 11
3	6 14	6 14	6 15	6 15	6 16	6 17
4	6 18	6 19	6 20	6 21	6 21	6 22
5	6 23	6 24	6 25	6 26	6 27	6 28
6	6 28	6 29	6 30	6 31	6 32	6 33
7	6 32	6 34	6 35	6 36	6 38	6 39
8	6 37	6 39	6 40	6 41	6 43	6 45
9	6 42	6 44	6 45	6 47	6 49	6 50
10	6 47	6 48	6 50	6 52	6 54	6 56
11	6 52	6 54	6 56	6 58	7 00	7 02
12	6 57	6 59	7 01	7 03	7 06	7 08
13	7 02	7 04	7 06	7 09	7 11	7 14
14	7 07	7 09	7 12	7 14	7 17	7 20
15	7 12	7 14	7 17	7 20	7 23	7 27
16	7 17	7 20	7 23	7 26	7 29	7 33
17	7 22	7 25	7 29	7 32	7 36	7 40
18	7 28	7 31	7 35	7 38	7 42	7 46
19	7 33	7 37	7 41	7 45	7 49	7 53
20	7 39	7 43	7 47	7 51	7 56	8 00
21	7 45	7 49	7 53	7 58	8 02	8 08
22	7 51	7 55	8 00	8 05	8 10	8 15
23	7 57	8 02	8 06	8 12	8 17	8 23
23.29	8 00	8 05	8 10	8 16	8 21	8 27

Double

Double the Time of Sun's { Setting, / Rising, } gives the Length of the { Day. / Night.

Sun's Declinat. Degrees of Declination.	The Degrees of Latitude.											
	55		56		57		58		59		60	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
0	6	00	6	00	6	00	6	00	6	00	6	00
1	6	06	6	06	6	06	6	06	6	07	6	07
2	6	11	6	12	6	12	6	13	6	13	6	14
3	6	17	6	18	6	19	6	19	6	20	6	21
4	6	23	6	24	6	25	6	26	6	27	6	28
5	6	29	6	30	6	31	6	32	6	33	6	35
6	6	35	6	36	6	37	6	39	6	40	6	42
7	6	40	6	42	6	44	6	45	6	47	6	49
8	6	46	6	48	6	50	6	52	6	54	6	56
9	6	52	6	54	6	56	6	59	7	01	7	04
10	6	58	7	00	7	03	7	06	7	08	7	11
11	7	04	7	07	7	10	7	13	7	16	7	19
12	7	11	7	13	7	16	7	20	7	23	7	26
13	7	17	7	20	7	23	7	27	7	30	7	34
14	7	23	7	27	7	30	7	34	7	38	7	42
15	7	30	7	34	7	38	7	42	7	46	7	51
16	7	37	7	41	7	45	7	49	7	54	7	59
17	7	44	7	48	7	52	7	57	8	03	8	08
18	7	51	7	55	8	00	8	05	8	11	8	17
19	7	58	8	03	8	08	8	14	8	20	8	26
20	8	05	8	10	8	16	8	22	8	29	8	36
21	8	13	8	19	8	25	8	32	8	39	8	47
22	8	21	8	27	8	34	8	41	8	49	8	58
23	8	29	8	36	8	43	8	51	9	00	9	09
23.29	8	34	8	41	8	48	8	56	9	05	9	14

A TABLE *shewing the Longest Day in every Degree of Latitude.*

Lat.	Longest Day.			Lat.	Longest Day.			Lat.	Longest Day.		
Deg.	H.	M.	S.	Deg.	H.	M.	S.	Deg.	H.	M.	S.
1	12	3	28	26	13	38	00	51	16	19	52
2	12	6	57	27	13	42	44	52	16	30	52
3	12	10	24	28	13	46	16	53	16	41	52
4	12	14	00	29	13	51	36	54	16	54	08
5	12	17	28	30	13	56	16	55	17	07	04
6	12	20	56	31	14	01	12	56	17	21	04
7	12	24	48	32	14	06	08	57	17	36	16
8	12	28	00	33	14	11	12	58	17	52	48
9	12	32	36	34	14	16	24	59	18	10	48
10	12	35	12	35	14	21	52	60	18	30	56
11	12	38	48	36	14	27	20	62	19	18	24
12	12	42	41	37	14	33	04	64	20	24	24
13	12	46	08	38	14	37	36	66	22	20	40
14	12	49	44	39	14	44	56	Deg	D.	H.	M.
15	12	53	28	40	14	51	12	68	42	01	40
16	12	57	20	41	14	57	44	70	64	13	46
17	13	01	04	42	15	04	24	72	82	06	36
18	13	04	46	43	15	11	20	74	96	17	00
19	13	08	56	44	15	18	40	76	110	07	27
20	13	12	48	45	15	26	08	78	122	17	06
21	13	16	48	46	15	34	08	80	134	04	58
22	13	21	04	47	15	42	24	83	151	02	06
23	13	25	04	48	15	51	04	86	166	11	23
24	13	29	20	49	16	00	08	89	181	21	58
25	13	33	35	50	16	09	24	90	187	06	39

A

TABLE

OF THE

SUN's Amplitude East or West, from the Equinoctial to 60 Degrees of Latitude, either North or South.

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude, either North or South.

Sun's Declinat.	The Degrees of Latitude.											
	1		2		3		4		5		6	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
1	1.	0	1.	0	1.	0	1.	0	1.	0	1.	0
2	2.	0	2.	0	2.	0	2.	0	2.	0	2.	0
3	3.	0	3.	0	3.	0	3.	0	3.	0	3.	1
4	4.	0	4.	0	4.	0	4.	0	4.	1	4.	1
5	5.	0	5.	0	5.	0	5.	0	5.	1	5.	1
6	6.	0	6.	0	6.	0	6.	1	6.	1	6.	2
7	7.	0	7.	0	7.	0	7.	1	7.	1	7.	2
8	8.	0	8.	0	8.	1	8.	1	8.	2	8.	2
9	9.	0	9.	0	9.	1	9.	1	9.	2	9.	2
10	10.	0	10.	0	10.	1	10.	1	10.	2	10.	3
11	11.	0	11.	0	11.	1	11.	1	11.	2	11.	3
12	12.	0	12.	0	12.	1	12.	1	12.	3	12.	4
13	13.	0	13.	0	13.	1	13.	1	13.	3	13.	4
14	14.	0	14.	0	14.	1	14.	2	14.	3	14.	4
15	15.	0	15.	0	15.	1	15.	2	15.	3	15.	5
16	16.	0	16.	0	16.	1	16.	2	16.	4	16.	5
17	17.	0	17.	1	17.	1	17.	2	17.	4	17.	5
18	18.	0	18.	1	18.	1	18.	2	18.	4	18.	6
19	19.	0	19.	1	19.	1	19.	2	19.	4	19.	6
20	20.	0	20.	1	20.	2	20.	3	20.	5	20.	6
21	21.	0	21.	1	21.	2	21.	3	21.	5	21.	7
22	22.	0	22.	1	22.	2	22.	3	22.	5	22.	7
23	23.	0	23.	1	23.	2	23.	3	23.	5	23.	8
23,29	23.	29	23.	30	23.	33	23.	35	23.	37	23.	39

Degrees of Declination.

When

When { True & / Magn. } Amplitudes are { the / not the } { same } —

There's no / Diff. is the { Variation of the Compaſs.

Sun's Declinat.	The Degrees of Latitude.					
	7	8	9	10.	11.	12.
Degrees of Declination.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.
0	0. 0	0. 1	0. 0	0. 0	0. 0	0. 0
1	1. 0	1. 0	1. 0	1. 1	1. 1	1. 1
2	2. 1	2. 1	2. 1	2. 2	2. 2	2. 3
3	3. 1	3. 1	3. 1	3. 3	3. 3	3. 4
4	4. 2	4. 2	4. 2	4. 4	4. 4	4. 5
5	5. 2	5. 6	5. 3	5. 5	5. 5	5. 7
6	6. 2	6. 3	6. 4	6. 6	6. 6	6. 8
7	7. 3	7. 4	7. 5	7. 7	7. 8	7. 9
8	8. 3	8. 4	8. 6	8. 8	8. 9	8. 11
9	9. 4	9. 5	9. 6	9. 9	9. 10	9. 12
10	10. 4	10. 6	10. 7	10.10	10.11	10.13
11	11. 5	11. 6	11. 8	11.11	11.13	11.15
12	12. 5	12. 7	12. 9	12.12	12.14	12.16
13	13. 6	13. 8	13. 9	13.13	13.15	13.17
14	14. 6	14. 8	14.10	14.14	14.16	14.19
15	15. 7	15. 9	15.11	15.15	15.17	15.20
16	16. 7	16.10	16.12	16.16	16.19	16.22
17	17. 8	17.10	17.13	17.17	17.20	17.23
18	18. 8	18.11	18.14	18.18	18.21	18.25
19	19. 9	19.12	19.15	19.19	19.22	19.26
20	20. 9	20.12	20.16	20.20	20.24	20.28
21	21.10	21.13	21.17	21.21	21.25	21.29
22	22.10	22.13	22.18	22.22	22.27	22.31
23	23.11	23.14	23.19	23.23	23.28	23.33
23.29	23.42	23.46	23.50	23.54	23.59	24. 5

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude, either North or South.

Sun's Declinat. Degrees of Declination.	The Degrees of Latitude.											
	13		14		15		16		17		18	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	2	1	2	1	2	1	2	1	2	1	3
2	2	3	2	4	3	4	2	5	2	5	2	6
3	3	5	3	5	3	6	3	7	3	8	3	9
4	4	6	4	7	4	8	4	10	4	11	4	12
5	5	8	5	9	5	10	5	12	5	13	5	15
6	6	10	6	11	6	13	6	15	6	17	6	19
7	7	11	7	13	7	15	7	17	7	19	7	22
8	8	13	8	15	8	17	8	19	8	22	8	25
9	9	14	9	17	9	19	9	22	9	25	9	28
10	10	16	10	19	10	21	10	24	10	28	10	31
11	11	17	11	20	11	23	11	27	11	30	11	34
12	12	19	12	22	12	25	12	29	12	33	12	38
13	13	20	13	24	13	27	13	32	13	36	13	41
14	14	22	14	26	14	30	14	34	14	39	14	44
15	15	24	15	28	15	32	15	37	15	42	15	47
16	16	26	16	30	16	35	16	40	16	45	16	51
17	17	28	17	32	17	37	17	42	17	48	17	54
18	18	30	18	34	18	39	18	44	18	51	18	58
19	19	31	19	36	19	42	19	48	19	54	20	1
20	20	33	20	38	20	44	20	51	21	57	21	4
21	21	35	21	40	21	46	21	53	22	0	22	8
22	22	37	22	43	22	49	22	56	23	4	23	12
23	23	39	23	45	23	51	23	58	24	6	24	15
23.29	24	11	24	17	24	24	24	32	25	40	24	49

In counting both Amplitudes from the North,

Observe, If { true / Mag. } ⊙ Amp. greateſt, at { East / West } ⊙ rising Var. is { East / West } at ⊙ { West. / East. } ſett.

Sun's Declinat.	The Degrees of Latitude.											
	19		20		21		22		23		24	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	3	1	4	1	4	1	5	1	5	1	6
2	2	7	2	8	2	8	2	9	2	10	2	12
3	3	10	3	12	3	13	3	14	3	15	3	17
4	4	14	4	16	4	17	4	19	4	21	4	23
5	5	17	5	19	5	21	5	23	5	26	5	28
6	6	21	6	23	6	26	6	28	6	31	6	34
7	7	24	7	27	7	30	7	3	7	37	7	40
8	8	28	8	31	8	34	8	38	8	42	8	46
9	9	31	9	35	9	39	9	43	9	47	9	51
10	10	35	10	39	10	43	10	48	10	52	10	57
11	11	38	11	43	11	48	11	53	11	58	11	3
12	12	42	12	47	12	52	12	58	13	3	13	9
13	13	46	13	51	13	57	14	3	14	9	14	15
14	14	50	14	55	15	1	15	8	15	14	15	21
15	15	53	16	0	16	6	16	13	16	20	16	27
16	16	57	17	4	17	11	17	18	17	26	17	34
17	18	1	18	8	18	15	18	23	18	31	18	40
18	19	5	19	12	19	20	19	28	19	37	19	46
19	20	8	20	16	20	24	20	33	20	42	20	52
20	21	12	21	20	21	29	21	39	21	49	21	59
21	22	16	22	25	22	34	22	44	22	55	23	7
22	23	20	23	29	23	39	23	50	24	1	24	12
23	24	24	24	34	24	44	24	55	25	7	25	19
23.29	24	58	25	8	25	18	25	29	25	41	25	54

Degrees of Declination.

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude either North or South.

Sun's Declinat. Degrees of Declination.	The Degrees of Latitude.											
	25		26		27		28		29		30	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	6	1	7	1	8	1	8	1	9	1	9
2	2	12	2	13	2	15	2	16	2	17	2	18
3	3	18	3	20	3	22	3	24	3	26	3	28
4	4	25	4	27	4	29	4	32	4	34	4	37
5	5	31	5	34	5	37	5	40	5	43	5	46
6	6	37	6	41	6	44	6	48	6	52	6	56
7	7	43	7	47	7	51	7	56	8	1	8	6
8	8	50	8	54	8	59	9	4	9	9	9	15
9	9	56	10	1	10	6	10	12	10	18	10	24
10	11	3	11	8	11	14	11	21	11	27	11	34
11	12	9	12	15	12	21	12	28	12	36	12	44
12	13	16	13	28	13	30	13	37	13	45	13	53
13	14	22	14	30	14	37	14	45	14	54	15	3
14	15	29	15	37	15	45	15	54	16	3	16	12
15	16	35	16	44	16	53	17	3	17	12	17	23
16	17	42	17	51	18	1	18	11	18	21	18	32
17	18	49	18	59	19	9	19	20	19	31	19	43
18	18	56	20	6	20	17	20	29	20	41	20	54
19	21	2	21	13	21	25	21	38	21	51	22	5
20	22	10	22	22	22	34	22	48	23	2	23	16
21	23	18	23	30	23	43	23	57	24	12	24	27
22	24	24	24	37	24	51	25	6	25	22	25	38
23	25	32	25	46	26	1	26	16	26	32	26	49
23 29	26	8	26	23	26	29	26	46	27	3	27	21

Amplitudes of {one / different} kind. their {Difference / Sum} is the Variation of the Compass.

Degrees of Declination. Sun's Declinat.	The Degrees of Latitude.											
	31		32		33		34		35		36	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	0	0	0	0	00	0	00	0	00	0	00
1	1	10	1	10	1	11	1	12	1	13	1	14
2	2	19	2	21	2	23	2	25	2	27	2	29
3	3	30	3	33	3	35	3	38	3	40	3	43
4	4	40	4	43	4	46	4	50	4	53	4	57
5	5	50	5	54	5	58	6	02	6	06	6	11
6	7	00	7	05	7	10	7	15	7	20	7	25
7	8	11	8	16	8	21	8	27	8	33	8	40
8	9	21	9	27	9	33	9	39	9	46	9	54
9	10	31	10	38	10	45	10	52	11	00	11	08
10	11	41	11	48	11	55	12	03	12	12	12	21
11	12	52	13	00	13	09	13	18	13	28	13	39
12	14	02	14	11	14	21	14	32	14	43	14	54
13	15	13	15	23	15	33	15	44	15	56	16	09
14	16	22	16	33	16	45	16	57	17	10	17	24
15	17	34	17	46	17	58	18	11	18	25	18	40
16	18	44	18	57	18	11	19	25	19	40	19	55
17	19	56	20	10	20	24	20	39	20	55	20	11
18	21	07	21	21	21	36	22	53	22	10	22	27
19	22	19	22	34	22	50	23	07	23	25	23	44
20	23	31	23	47	24	04	24	22	24	41	25	00
21	24	43	25	00	25	18	25	37	25	56	26	17
22	25	55	26	13	26	32	26	52	27	13	27	35
23	27	07	27	26	27	46	28	07	28	29	28	52
23.29	27	04	28	00	28	21	28	43	29	07	29	31

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude either North or South.

Sun's Declinat. Degrees of Declination.	The Degrees of Latitude.											
	37		38		39		40		41		42	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	00	0	00	0	00	0	00	0	00	0	00
1	1	15	1	16	1	17	1	18	1	20	1	21
2	2	30	2	32	2	34	2	36	2	39	2	41
3	3	45	3	48	3	51	3	54	3	58	4	02
4	5	00	5	04	5	08	5	13	5	18	5	23
5	6	16	6	21	6	26	6	32	6	38	6	44
6	7	31	7	37	7	43	7	50	7	57	8	05
7	8	47	8	54	9	01	9	09	9	17	9	26
8	10	02	10	10	10	19	10	28	10	37	10	47
9	11	17	11	27	11	37	11	47	11	58	12	09
10	12	32	12	43	12	34	13	6	13	18	13	31
11	13	50	24	01	14	13	14	26	14	39	14	53
12	15	06	15	18	15	31	15	45	16	00	16	15
13	16	22	16	35	16	49	17	04	17	20	17	37
14	17	38	17	52	18	08	18	24	18	42	19	00
15	18	55	19	11	19	28	19	45	20	04	20	23
16	20	11	20	28	20	46	21	05	21	25	21	46
17	21	28	21	46	22	06	22	26	22	48	23	10
18	22	46	23	05	23	25	23	47	24	10	24	34
19	24	04	24	24	24	46	25	09	25	33	25	58
20	25	21	25	43	26	06	26	30	26	56	27	24
21	26	39	27	02	27	27	27	53	28	21	28	50
22	27	58	28	23	28	49	29	16	29	45	30	16
23	29	17	29	43	30	11	30	40	31	11	31	43
23.29	29	57	30	24	30	52	31	22	31	54	32	28

If true Ampl. be to the { Right / Left } of the Magn. Ampl. { East. / West. } the Variation is

Sun's Declinar.	The Degrees of Latitude.											
	43		44		45		46		47		48	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	00	0	00	0	00	0	00	0	00	0	00
1	1	22	1	23	1	25	1	26	1	28	1	29
2	3	44	2	47	2	50	2	53	2	56	2	59
3	4	06	4	10	4	15	4	19	4	24	4	29
4	5	28	5	34	5	40	5	46	5	52	5	59
5	6	51	6	58	7	05	7	12	7	20	7	29
6	8	13	8	21	8	30	8	39	8	49	8	59
7	9	35	9	45	9	56	10	06	10	18	10	30
8	10	58	11	09	11	21	11	34	11	47	12	00
9	12	21	13	34	12	47	13	01	13	16	13	31
10	13	44	13	58	14	13	14	28	14	44	15	02
11	15	07	15	22	15	38	15	55	16	15	16	34
12	16	31	16	48	17	09	17	25	17	45	18	06
13	17	55	18	13	18	33	18	54	19	16	19	39
14	19	18	19	39	20	00	20	23	20	47	21	12
15	20	43	21	05	21	28	21	52	22	18	22	45
16	22	08	22	32	22	56	23	23	23	50	24	20
17	23	34	23	59	24	25	24	53	25	23	25	55
18	24	59	25	26	25	54	26	25	26	57	27	31
19	26	25	26	54	27	25	27	58	28	32	29	07
20	27	53	28	23	28	56	29	31	30	07	30	45
21	29	20	29	53	30	27	31	03	31	42	32	23
22	30	48	31	22	31	58	32	37	33	18	34	03
23	32	16	32	51	33	30	34	12	34	56	35	43
23.29	33	03	33	40	34	20	35	03	35	48	36	35

Degrees of Declination.

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude, either North or South.

Sun's Declinat.	The Degrees of Latitude.											
	49		50		51		52		53		54	
Degrees of Declination.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	00	0	00	0	00	0	00	0	00	0	00
1	1	31	1	33	1	35	1	37	1	39	1	42
2	3	03	3	06	3	10	3	15	3	20	3	24
3	4	34	4	40	4	46	4	52	4	59	5	06
4	6	06	6	14	6	22	6	30	6	39	6	49
5	7	38	7	48	7	58	8	08	8	19	8	31
6	9	10	9	21	9	33	9	46	10	00	10	15
7	10	42	10	55	11	09	11	24	11	40	11	57
8	12	14	12	29	12	45	13	02	13	21	13	41
9	13	47	14	05	14	24	14	43	15	04	15	26
10	15	21	15	40	16	01	16	23	16	46	17	11
11	16	54	17	16	17	39	18	03	18	29	18	57
12	18	28	18	52	19	18	19	44	20	12	20	43
13	20	06	20	29	20	57	21	26	21	57	22	30
14	21	45	22	06	22	37	23	08	23	42	24	18
15	23	14	23	45	24	18	24	52	25	28	26	07
16	24	51	25	22	25	59	26	36	27	16	27	58
17	26	28	27	03	27	41	28	21	29	04	29	50
18	28	06	28	43	29	24	30	07	30	53	31	42
19	29	45	30	25	31	08	31	55	32	45	33	38
20	31	25	32	08	32	54	33	46	34	39	35	35
21	33	06	33	52	34	41	35	34	36	31	37	32
22	34	48	35	37	36	30	37	27	38	29	39	36
23	36	33	37	26	38	23	39	24	40	29	41	40
23.29	37	26	38	20	39	19	40	23	41	32	42	46

A Table of the Sun's Amplitude East or West, fitting all Places from the Equinoctial to 60 Degrees of Latitude, either North or South.

Sun's Declinat.	The Degrees of Latitude.											
	55		56		57		58		59		60	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
0	0	00	0	00	0	00	0	00	0	00	0	00
1	1	45	1	47	1	50	1	53	1	56	2	00
2	3	29	3	34	3	40	3	46	3	53	4	00
3	5	14	5	22	5	31	5	40	5	50	6	00
4	6	59	7	10	7	22	7	34	7	47	8	01
5	8	44	8	57	9	11	9	26	9	43	10	02
6	10	30	10	47	11	04	11	22	11	42	12	04
7	12	15	12	35	12	56	13	18	13	41	14	06
8	14	02	14	24	14	48	15	14	15	41	16	10
9	15	49	16	14	16	41	17	10	17	41	18	14
10	17	37	18	05	18	35	19	07	19	41	20	18
11	19	26	19	56	20	29	21	04	21	43	22	26
12	21	15	21	49	22	25	23	04	23	47	24	34
13	23	05	23	03	24	23	25	07	23	54	26	45
14	24	56	25	37	26	21	27	09	28	01	28	56
15	26	49	27	34	28	22	29	14	30	10	31	10
16	28	43	29	32	30	24	31	21	32	22	33	27
17	30	39	31	31	32	27	33	28	34	32	35	47
18	32	35	33	33	34	34	35	40	36	52	38	10
19	34	35	35	36	36	43	37	54	39	13	40	37
20	36	36	37	42	38	53	40	12	41	37	43	10
21	38	39	39	51	41	09	42	34	44	05	45	47
22	40	47	42	04	43	27	44	59	46	40	48	32
23	42	56	44	19	45	50	47	30	49	21	51	24
23.29	44	06	45	32	47	05	48	49	50	44	52	53

Degrees of Declination.

Days	Jan. ☉right Aſcen.		Febr. ☉right Aſcen.		March ☉right Aſcen.		April. ☉right Aſcen.		May. ☉right Aſcen.		June. ☉right Aſcen.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
1	19.	36	21.	43	23.	29	1.	02	3.	15	5.	20
2	19.	40	21.	47	23.	33	1.	26	3.	19	5.	24
3	19.	44	21.	51	23.	37	1.	30	3.	23	5.	28
4	19.	49	21.	55	23.	40	1.	34	3.	27	5.	32
5	19.	53	21.	59	23.	44	1.	37	3.	31	5.	37
6	19.	57	22.	3	23.	47	1.	41	3.	35	5.	41
7	20.	1	22.	7	23.	51	1.	45	3.	39	5.	45
8	20.	5	22.	11	23.	54	1.	48	3.	43	5.	49
9	20.	9	22.	15	23.	58	1.	52	3.	47	5.	53
10	20.	14	22.	18	0.	02	1.	55	3.	51	5.	57
11	20.	18	22.	22	0.	06	1.	59	3.	55	6.	1
12	20.	23	22.	26	0.	09	2.	3	3.	59	6.	5
13	20.	27	22.	30	0.	13	2.	7	4.	3	6.	9
14	20.	31	22.	34	0.	16	2.	11	4.	7	6.	13
15	20.	35	22.	37	0.	20	2.	14	4.	11	6.	18
16	20.	39	22.	41	0.	24	2.	18	4.	15	6.	22
17	20.	43	22.	45	0.	27	2.	22	4.	19	6.	27
18	20.	47	22.	49	0.	31	2.	26	4.	23	6.	30
19	20.	51	22.	53	0.	34	2.	30	4.	27	6.	34
20	20.	55	22.	56	0.	38	2.	33	4.	31	6.	39
21	20.	59	23.	0	0.	42	2.	37	4.	35	6.	43
22	21.	4	23.	0	0.	45	2.	41	4.	39	6.	47
23	21.	8	23.	4	0.	49	2.	45	4.	43	6.	51
24	21.	12	23.	11	0.	53	2.	49	4.	47	6.	55
25	21.	16	23.	14	0.	56	2.	52	4.	51	6.	59
26	21.	20	23.	18	1.	00	2.	56	4.	55	7.	3
27	21.	24	23.	22	1.	04	3.	00	4.	59	7.	7
28	21.	28	23.	26	1.	07	3.	4	5.	3	7.	11
29	21.	32			1.	11	3.	8	5.	7	7.	15
30	21.	36			1.	15	3.	11	5.	12	7.	20
31	21.	39			1.	18			5.	16		

Days.	July. ☉ right Aſcen.		Aug. ☉ right Aſcen.		Sept. ☉ right Aſcen.		Octob. ☉ right Aſcen.		Nov. ☉ right Aſcen.		Dec. ☉ right Aſcen.	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
1	7.	24	9.	26	11.	20	13.	10	15.	11	17.	16
2	7.	28	9.	30	11.	24	13.	14	15.	15	17.	21
3	7.	32	9.	34	11.	27	13.	18	15.	19	17.	26
4	7.	36	9.	38	11.	31	13.	22	15.	23	17.	30
5	7.	40	9.	41	11.	34	13.	26	15.	27	17.	35
6	7.	44	9.	45	11.	37	13.	30	15.	31	17.	39
7	7.	48	9.	49	11.	42	13.	34	15.	35	17.	43
8	7.	52	9.	52	11.	45	13.	38	15.	39	17.	47
9	7.	56	9.	56	11.	49	13.	41	15.	43	17.	52
10	8.	0	9.	59	11.	51	13.	45	15.	47	17.	57
11	8.	4	10.	3	11.	55	13.	49	15.	51	18.	1
12	8.	8	10.	7	11.	59	13.	53	15.	54	18.	6
13	8.	12	10.	11	12.	3	13.	57	15.	59	18.	10
14	8.	16	10.	15	12.	7	14.	0	16.	3	18.	15
15	8.	20	10.	18	12.	10	14.	4	16.	8	18.	20
16	8.	24	10.	22	12.	14	14.	8	16.	12	18.	24
17	8.	28	10.	26	12.	18	14.	13	16.	16	18.	29
18	8.	32	10.	29	12.	22	14.	16	16.	20	18.	34
19	8.	36	10.	33	12.	25	14.	20	16.	24	18.	38
20	8.	40	10.	36	12.	28	14.	24	16.	29	18.	42
21	8.	44	10.	40	12.	32	14.	28	16.	33	18.	46
22	8.	48	10.	44	12.	36	14.	32	16.	37	18.	50
23	8.	52	10.	48	12.	39	14.	36	16.	41	18.	55
24	8.	56	10.	51	12.	43	14.	39	16.	45	18.	59
25	8.	59	10.	54	12.	47	14.	43	16.	50	19.	4
36	9.	3	10.	58	12.	50	14.	47	16.	54	19.	8
27	9.	7	11.	2	12.	54	14.	51	16.	58	19.	12
28	9.	11	11.	5	12.	58	14.	55	17.	3	19.	17
29	9.	15	11.	9	13.	2	14.	59	17.	7	19.	21
30	9.	18	11.	12	13.	6	15.	3	17.	12	19.	26
31	9.	22	11.	16			15.	7			19.	31

A TABLE *ſhewing the Semi-diurnal Arks, Seaſons for Obſerving, Right Aſcenſion and Declination of ſome Principal Fixed Stars.*

Names of the Stars.	*Mag.*	*Semi-diur. Arks.*	*Seaſon.*	*Right Aſcen.*	*Declin.*
		H.M	M. D.	H.M.	D. M.
Pole-Star.	2	ſet.not	Dec. 5	00.32	87.33N
Upper of the Pointers.	2	D°.	Feb. 17	10.43	63.32N
Lower of the Pointers.	2	D°.	Feb. 16	10.41	58. 8N
Bright * in the N°. Crown.	2	D°.	May 3	15.21	47.43N
Arcturus.	1	7.55	Apr. 12	14.02	20.54N
Bull's Eye, *Aldebaran.*	1	7.22	Nov.17	4.18	15.50N
Brighteſt 7 Stars, *Pleiades.*	3	8.10	Nov. 6	3.29	22.55N
Orion's Right Shoulder.	2	6.31	Dec. 6	5.39	7.18N
Firſt in *Orion*'s Belt.	3	5.55	Dec. 1	5.15	0.35 S
Orion's Right Foot Regal.	1	5.06	Nov.27	5.01	8.37 S
Mouth of the Great Dog *Syrius.* --- ------	1	4.34	Dec. 17	6.32	16.20 S

Head
*B
* * >
* A
Foot

Of the Croſiers or Croſs; when the Star A is perpendicular to Star B, then it is fit time to obſerve the Croſs's Foot A. This is moſt commonly uſed by our Weſt, Eaſt-Indies and *Guiney*-Navigators.

A Table for the Croſiers.	Rt. Aſc. H. M. S.	Declin. D. M. S.	Mag.
The Preceding of the two Middlemoſt in the Croſs --- --- ---	12.01.26	57.10.37	3
The Southermoſt of the Croſs	12.12.20	61.31.16	2
The Northermoſt of the Foot	12.16.41	55.30.10	2
The following or Eaſtermoſt of the Four ---- --- ---	12.26.03	58.05.57	1

A Table of the Latitude and Longitude of the Principal Harbours, Headlands and Iſlands in the World; Corrected by the lateſt and beſt Obſervations; the Beginning of the ſaid Longitude being accounted from the Meridian of LONDON.

N B. *The Latitude and Longitude of any Iſland ſet down hereunder, is meant of the Middle thereof, except ſome Part of it be expreſs'd or nam'd.*

Places Names.	Nor. Latit.	Weſt Lon.
The Coaſt of ENGLAND.	D.M.	D.M.
BErwick	55.50	01.39
Newcaſtle	54.58	01.30
Shelles	55.02	01.20
Sunderland	54.52	01.20
Hartlepool	54.40	00.55
Whitby	54.35	00.40
Scarborough	54.20	00.03
Stockton	54.33	01.25
Hull	53.45	00.28
	Nor. Latit.	Eaſt Lon.
Flamborough-Head	54.08	00.11
Burlington	54.00	00.06
Spurn	53.35	00.30
Grimesby	53.39	00.56
Boſton	53.09	00.10

Places Names.	Nor. Latit.	Eaſt Lon.
The Coaſt of ENGLAND.	D.M.	D.M.
Linn	52.56	00.29
Wells	53.07	01.00
Blackney	53.24	00.55
Cromer	53.10	01.07
Winterton	53.02	01.22
Yarmouth	52.45	01.40
Alborough	52.24	01.25
Orfordneſs	52.20	01.11
Ipſwich	52.14	01.00
Harwich	52.11	01.18
Colcheſter	52.04	00.58
LONDON	51.32	00.00
Rocheſter	51.28	00.25
Margate	51.29	01.10
North Foreland	51.28	01.10

Places Names.	Nor. Latit.	East Lon.
The Coaſt of *England.*	D.M.	D.M.
Sandwich	51.27	1. 09
The Downs	51.25	1. 21
South Foreland	51.12	1. 20
Ripraps	51.53	1. 25
Dover	51.15	1. 18
Dungeneſs.	51. 0	0. 51
Rye	51. 3	0. 45
Beachy	50.48	0. 25
	Nor. Latit.	Weſt Lon.
Shoreham	50.55	0. 17
Portſmouth	50.48	1. 00
Dunnoſe I. Wight.	50.38	1. 23
Pool	51. 0	1. 50
Weymouth	50.43	2. 40
Portland	50.30	2. 48
Chiddock	50.47	3. 00
Lime	50.45	3. 14
Topſham	50.37	3. 27
The Berry Head	50.25	3. 49
Torbay	50.32	3. 38
Dartmouth	50.27	3. 36
Start Point	50. 7	3. 45
The Eddyſtone	50 12	4. 20
Plymouth	50.36	4. 13
Ramhead	50.14	4. 35
Foy	50.25	4. 30

Places Names.	Nor. Latit.	Weſt Lon.
Coaſt of *England.* from the *Lizard* to *Holy-Head.*	D.M	D.M.
Falmouth	50.12	5. 12
Lizard	49.55	5. 14
St. Mary's Scilly	49.57	6. 45
Lands End	50. 6	6. 0
Gulf	50. 0	6. 6
Seven Stones	50. 5	6. 40
Hartland Point	51. 6	4. 35
Londey-Iſle	51.20	4. 40
Mort-Bay	51.12	4. 40
Briſtol	51.32	2. 35
Swanſey	51.40	4. 25
Caldy Iſland	51.33	5. 14
Milford	51.45	5. 15
St. David's Head	51.55	5. 22
Barſey Iſle	52.40	5. 10
Leverpool	53.20	3. 10
Weſtcheſter	53.37	4. 20
Lancaſter	54.40	3. 35
White-Haven	54.10	3. 50
Iſle of Man W. End	53.45	5. 0
Holy-Head	53.23	4. 40
Sea-Coaſts of *Scotland.*		
Glaſcow	55.53	4. 5
North Part of Sky-Iſland.	57.50	5. 21

Places

Places Names.	Nor. Latit.	West Lon
Coast of *Scotland.*	D.M.	D.M.
N. Part Lewis Isle	58.20	7. 15
St. Kilda	58. 2	10. 5
Farra Head	58.2[illegible]	5. 5
Shetland S. Point	59.5[illegible]	3. 39
Fair Isle	59.30	3. 20
Orkney Isles	59.13	3. 32
Cat-Ness	58.47	2. 6
Buchan-Ness	57.55	1. 20
Aberdeen	57 24	1. 37
Dundee	56.30	2. 36
Edenburgh	55.57	2. 46
Leith	56. 0	2. 55
Sea-Coasts of *Ireland.*		
Fair Foreland	55. 5	6. 30
London-Derry	54.55	8. 0
Belfast	54.36	6. 50
Island Torre	55. 8	8. 30
Isles of Arran	54.48	8. 59
Stags of Bra. Haven	54. 7	10. 5
Sline Head	53.20	11.15
Galloway.	53. 5	9. 20
Gally or Doens Hd.	52.40	9. 30
Lupis's Head	52.24	10.15
Limerick	52.22	9. 48
Blasques	52. 0	11.55
Skillocks	51.30	11.55
Cow and Calf	51.22	10.36

Places Names	Nor. Latit.	West Lon.
Sea-Coasts of *Ireland.*	D.M.	D.M.
Mizon Head	51.15	11.30
Old Head Kinsale	51.35	8. 58
Cape Clear	51.10	10.30
Cork	51.49	9. 30
Waterford	52. 7	7. 52
Wexford	52.13	7. 16
Lambay	53.24	7. 30
DUBLIN	53.20	7. 6
Sea-Coasts of *Holland & Flanders.*		East Lon.
Heligland	54.28	8. 35
Scaw	57.26	10.10
Hamborough	53.41	10.24
Bremen	53.50	8. 0
Emden	53. 5	8. 0
Ameyland	53.40	6. 40
Schelling	53.25	5. 50
The Fly	53.18	5. 35
The Texel	53.10	4. 59
Amsterdam	52.21	4. 51
Roterdam	51.55	4. 21
Antwerp	51.17	4. 32
The Brill	51.56	4. 10
Middleburgh	51.48	4. 0
Sluys	51.19	3. 50
Ostend	51.30	3. 5
Dunkirk	51.18	2. 25
Callis	50.57	2. 0
Diep in France	49.56	1. 6

Places Names.	Nor. Latit.	West Lon.
Coaſt of *France* and *Portugal.*	D.M.	D.M.
Cape de Hague	49.46	2. 06
Caskets	49.50	2. 32
Guernſey	49.36	2. 40
Jerſey	49.20	2. 19
St. Maloes	48.35	1. 5
Morlaix	48.37	3. 50
Uſhant	48.30	5. 5
Breſt	48.22	4. 24
Penmark	47.48	4. 15
Bell Iſle	47.20	3. 10
Nants	47.14	1. 49
Rochel	46.10	1. 14
Bourdeaux	44.50	0. 24
Bilboa	43.30	3. 0
Cape Ortegal	44.02	7. 40
Cape Coruna	43.28	9. 20
Cape Finiſter	43.06	10. 0
Porta Port	41.18	9. 20
Burlings	39.39	10.15
Rock of Lisbon	38.54	10.20
Cape St. Vincent	37.00	9. 32
Cape St. Maria	36.58	9. 18
Cadiz	36.16	7 0
C. Trefalgar	36.10	6. 30
Coaſt on the Main Continent within the *Straits.*		
Gibralter	36.11	5. 43
Malaga	36.50	3. 17
Cape de Gat	37.03	2. 2

Places Names.	Nor. Latit.	East Lon.
Coaſt of *Spain.*	D.M.	D.M.
Cape Paul	37.58	0.22
Cape Martin	59.00	0.28
Alicant	38.30	0. 35
Barcelona	41.30	2. 21
Marſeilles	43.20	5. 15
Toulon	43. 6	5. 40
Genoa	44.25	8. 40
Leghorne	43.18	10.29
Civita Vechia	41.46	12. 0
Rome	41.51	12.28
Naples	41. 5	14.28
Cape Sparta-vento	38. 0	16.58
C. Collone	39.10	18. 0
Gallipoli	40. 8	18.39
C. St. Mary	39.56	19. 0
Ancona	43.31	14.40
Venice	45.18	13.10
Lepanto	38.20	21.55
C. Matapan	36.35	22.20
C. St. Angelo	36.41	23.20
Athens	38. 0	24.29
C. Martelo, S.P. of Negropont.	38. 0	25.45
C. Monte Sancto	40. 5	26. 5
Gallipoli	40.30	27.58
Conſtantinople	41. 7	30. 0
Smyrna	38.30	27.25
Epheſus	37.54	27.15
Antiochetta	36.40	31.37
Scanderoon	36. 0	35.58
Tripoli	34.40	35.40
Alexandria	31. 7	30.50

Places Names.	Nor. Latit.	East Lon.
In the *Straits.*	D.M.	D.M
C. Rusato	33.15	21.55
C. Misorato	32 43	16.23
C. Bona	37. 5	10. 0
Bona	37 0	7. 0
Algier	36.40	3. 5
C. de tres forcas	35.34	2.25 W
Tetuan	35.28	5. 52
Seuta	35.55	5. 47
Tangier	35.55	6. 14
Islands within the *Straits.*		East Lon
Alboran	36.10	3. 0 W
Formentaria	38.44	1. 31
Ivica	39. 5	1. 30
Majorica City	39.48	2. 49
Minorca, P. Maon	40. 2	4. 25
S. End of Sardinia	38.46	9. 10
N. End of Sardinia	41. 0	10. 1
N. End of Corsica	42.57	9. 45
Gurgona	43.34	9. 38
Capita	43. 6	9. 40
Lilboa	42 44	10. 5
Messina	38.22	16.25
Maritimo	38.12	11.55
C. Passero	36.48	16. 4
Malta	36.10	14.49
Corfu	39.45	20.42
Chefalonia	38.15	21 49

Places Names.	Nor. Latit.	East Lon.
Isles in the *Straits.*	D.M	D.M.
Zant	37.47	22.10
Modon. Morea	36.52	21 32
Lemnos	39.50	25.27
Scio	38.20	23.31
C. St. John, W. end of Candy.	35.20	23.27
C. Solomen. E. end of Candy.	35.25	26.31
Rhodes City	36.40	28. 0
W. end of Cypress	35.21	31.35
E. end of Cypress.	35.35	34.25
Coast of *Barbaria* and *Guiney.*		West Lon.
C. Spartel	35.46	5. 55
Sallee	33.43	6. 30
C. Cantin	32.16	9. 20
C. de Geer	30.04	10.10
C. Bajador	26.12	14.30
C. Olerado	23.41	15.50
C. Blanco	20 35	16.55
Senegal	15.16	15.40
C. de Verde	14.30	16.26
River Gambia	13.16	15.20
Serralion	8 36	12.15
Monserado	6. 5	9. 20
C. Palmos	4. 3	5. 36
Jaque Jaque	4. 16	2. 30
Assene	4. 15	1. 0

Places Names.	Nor. Latit	East Lon.
Guinea Coaſt.	D.M.	D.M.
Cape Corce	4. 40	3. 10
C. Three Points	4. 13	0. 45
River Volto	5. 40	3. 30
R. Formoſa	7. 0	7. 40
C. Formoſa	4. 40	8. 0
New Callibar	4. 12	10.25
Old Callibar	3. 18	11.32
R. Camerones	4. 2	13 10
R. de Angra	0. 49	13.15
	South Latit.	
Lopas	1. 5	12.20
River Congo	5. 45	15.27
Angola	8. 51	15.56
Cape Negro	16. 8	14.46
C. St. Thomas	23.10	14.23
Secos	28.56	15.32
C. Bona Eſperance	34.25	17.25

Weſtern Iſlands.	Nor. Latit.	Weſt Lon.
Corvo	40. 5	29.55
Flores	39.40	29.50
Fyal	38.53	27.16
Pico	38.32	26.31
St. George	38.56	26.10
Gratioſa	39.30	28.15

Places Names.	Nor. Latit.	Weſt Lon.
Weſtern Iſlands.	D.M	D.M.
Tercera	38.53	24.42
St. Michael	38. 0	22.32
St. Maries	37. 0	22.17
Canary Iſles.		
Porto Sancta	32.50	15.50
Madera W. end	32.17	17.22
Ferro	28. 0	18.12
Palma	28.50	18. 0
Gomero	28. 8	17.26
Tenariff	28.20	16.45
Canaria	27.56	15.30
Fortaventura	27.54	13 24
Lancerota	28.32	12.54
Cape de Verd Iſles.		
St. Antonio	17.10	25.20
St. Vincent	16.55	25.10
St. Lucia	16 45	24.58
St. Nicholas	16.40	24.22
Iſle de Sal	17. 0	22.13
Iſle May	15. 0	22.16
St. Jago	15.20	23.10
Brava	14.35	24 38
Fuogo	14.42	24. 0
Bonaviſta	16. 5	21.55

Places Names.	South Latit.	West Lon.
Southern Isles.	D.M.	D M.
St. Matthews	1. 40	3. 55
Ascension	8. 10	12.53
St. Helena	16. 6	5. 40
	Nor. Latit.	East Lon.
Fernandepo	2. 35	11.55
Princeps	1. 25	11. 0
St. Thomas	0. 0	9. 58
Annabona	1.22S	9. 28
Coast of the Main Continent in the *East-Indies.*	South Latit.	
C. Lagullas	35.35	17.25
C. Corientes	23.52	35.35
Mosambique	15. 5	40.30
River de Fugos	0. 0	41.15
	Nor. Latit.	
Cape Bassos	4. 0	49.50
C. Guardafoy	11.50	52.30
C. Rosulgat.	22.27	60.45
Cape Muca	26.56	57.10

Places Names.	Nor. Latit.	East Lon.
East India.	D.M.	D.M.
Bussera	30. 0	49. 5
Surrat	21. 8	73.25
Goa	15.22	74.37
Calecute	11.17	75.54
Cochin	9. 58	76.45
C. Comarine	7. 50	78.25
Fort St. George	13. 8	81.42
Dew Point	15.50	82. 5
Visegapatum	17.40	85. 7
Bombay Isle	19. 0	73.15
C. Palmiris	20.45	88.10
Bengal	22.27	91.49
C. Negrais	16.23	93. 0
Malacca	2. 21	101.22
Cambodia Entrance	10.30	105.20
Siam Entrance	13.10	101. 1
Cochin	18.25	103.15
Cantam	23.30	113.20
Amoy Isle	24.25	116.55
Lampo	30.10	120.25
Namquin	32.55	120. 5
Islands in the *East Indies.*		
Madagascar, or *St. Lawrence South-End*	26. 6	46. 20
North-End	12.10	50. 10
Mayetta	13.10	45. 45
Mohilla	12.15	43. 41

Places

Places Names.	Nor. Latit.	East Lon.
East India Islands.	D.M.	D.M.
Malba	11.15	60.30
Comero	11.50	43.44
St. Juan de Nova	17 30	42.35
Mauritius	20. 5	55. 5
Digo Reyes	19.45	61.35
Romiras de Castelamos	29. 5	66.56
Amsterdam	39.50	74.24
St. Brandon	16.38	64.30
Digo gratiosa	8. 42	69. 5
Quabella	3. 49	52.39
Bassosde Chagos	5. 5	70.25
Yas de Digo Rays	0. 0	72. 5
	South Latit.	
Maldivia N. end	7. 5	73. 5
Maldivia S. end	1. 0	76.15
Malique	9. 0	73.15
Saccatra	12.28	55.37
Abdeleur	12.10	54.23
C. Gallo in Zeloan	6. 7	80.45
	Nor. Latit.	
Yas de Amber	0. 0	52.30
Andaman	13. 0	91.25
Nicobor	7. 5	92.55
Sumatra the N.W. End	5. 28	93.45
Verkins Isle	2. 22	94. 7

Places Names.	South Latit.	East Lon.
Isles in the *East Indies.*	D.M.	D.M.
Nassau Isle	2. 4	98.32
Bencola	3. 50	101.13
Sumatra the S. E. End	5. 42	104. 4
	5. 40	100.53
Engano	8. 20	102.13
Selam	6. 30	104. 2
Princes Isle	5. 47	105.11
Bantam in Java	5. 37	106.27
Batavia	8. 35	112.27
Java East end	5. 52	104 18
Straits of Sundy	3. 25	106.37
Banca South End	4. 14	112.52
Borneo South Point	5. 5	126.37
Bandy Isles	6. 0	117.27
Celebes South End	Nor. Latit.	
Celebes North End	1. 40	121.30
Mindano W. Point	6. 30	118.35
Borneo N. Point	7. 10	112.45
Luconio S. Point	12 30	120.50
Luconio N.E. Pt.	18.35	119. 5
Arain W. Point	19.30	108. 6
Arain E. Point	19.55	111.16
Formosa S. Point	22. 0	119.30
Formosa N. Point	25.32	120.25
Piscadore Isles	23.30	117.35
Island Chusan	30.38	120.35
Japan S. E. Point	39 50	135.15
Japan S.W. Point	39.10	126.55

Places Names.	Nor. Latit.	West Long.
The Coaſt of *America* in the *South Sea.*	D.M.	D. M
C. St. Sebaſtian	42.40	129.55
C. St. Luca	23.25	111.56
C. Corientes	19.40	110.30
Aquapulco	17. 0	106. 8
Aquatulco	15.27	101. 3
Guatimala	14.25	96 0
Panama	8. 56	82 18
Bay Bonaventuro	3. 28	80 6
Iſles of Gallopego	0. 0	90 10
	South Latit.	
Cape del Ajugo	16.38	88 50
Lima	12.30	73 30
Arica	18.12	74 10
La Serena	24.40	76 32
Ild Juan or Fernando	23.20	86 48
Baldivia	39.35	81 20
Port Steven	46.50	82 36
Cape Victory	52.15	83 20
Cape Horn	57.58	79 55
The Coaſt of *Brazile* in *South-America.*		
Magellan, the Eaſt Entrance	51.58	75 30
River Julian	48.40	74 32
Cape Blanco, near R. Camarones	46.50	72 5

Places Names.	South Latit.	West Lon.
Coaſt of *Brazile*, in *South-America.*	D.M.	D.M
Buenas Ares or River Plata	36.10	57.30
River Grand	31.55	51.40
St. Katherine's Iſle	28. 0	47.50
Cape Frio	23.10	42.56
Spirito Sancto	19.58	42. 0
P. Segura	16.22	40.58
Bay Todus Sanctus	13. 0	40.35
R. St. Franciſco	10.55	37.46
Cape St. Auguſtine	8. 5	35.38
Cape Roque	5. 0	35.52
Friſtan de Cunha	37. 5	15.38
Trinidada	0. 30	30. 0
Coaſt on the Main Continent in the *Weſt Indies.*	Nor. Latit.	Weſt Lon.
R. Amazones entr.	0. 0	49. 0
North Cape	2. 5	49.55
Surnam	6. 0	56.55
Oroonoque	8. 15	59. 5
C. Coquibaca	12.50	70.40
Carthagena	10.50	75.50
Scots Settlement	8. 30	58.45
Nicaraque Entr.	11.15	85. 5
Cape Catocha	21.22	88.55
Campeche	19.20	93. 5
La vera Cruz	19.15	100.25
Eſcondide	18.20	99. 0
Cape Florida	24 48	81.55
Miſſiſippi R. Mouth	28.30	96.10
Apalachia	29.47	85.48

Places Names.	Nor. Latit.	West Lon.
The *Caribbees*, or *West India* Islands.	D.M.	D.M.
Trinidada	10. 5	60. 5
Tobago	11.10	59.20
Granada	2. 7	60.30
Barbadoes	13 12	59.22
St. Lucia	13.52	59.17
Martinico	14.48	58.25
Dominico	15.35	58.27
Marigalante	15.53	58.20
Guardalupa	16.15	59.23
Monserat	16.40	59.35
Antegoa	17. 0	59.30
Nevis	17. 6	60.18
St. Christophers	17.22	60.35
Barbuda	17.43	59.25
St. Bartholomew	17.54	60.45
St. Martin's	18. 5	60.49
Anguilla	18.13	60.55
Virgins	18.23	62.22
St. Cruz	17.38	62.35
Bieque	18. 0	63.15
St. Thomas	18.30	63.22
Tortuga	20.15	72.54
Port Rico or *St. John's*	18.33	64.20
St. Dominica Hispaniola	18 15	68.50
P. Royal Jamaica	11. 0	77. 3
East end of Cuba	20.20	74. 5
Havana	22.50	83.30
Bay Honda	22.34	84.40
C. St. Antonia	21.50	86.32

Places Names.	Nor. Latit.	West Lon.
Bahama Isles.	D.M	D.M.
Bahama Isle	27. 5	78.58
Abbaca, S. Point	25.50	77.20
Harbour Island	25.40	76.35
Andros N. Point	25.15	79. 0
Providence.	25. 0	77.45
Illathera, S. Point	24.30	76.12
Cat Island	24 25	75.20
Watling Island	24. 7	74.50
Rum Key	23.45	75. 5
Exuma	23.25	76. 7
Crooked Isle, N. Pt.	23. 3	74. 0
Atkin's Key	22. 0	74.15
Metapervouz	21.57	74.40
Atwood's Keys	23. 9	73 30
French Keys	22.40	73.35
Mayaguana	22.35	73. 0
Hogsties	21.15	73.50
Hyneago	20.57	73.30
Cancos Bank, N. Point	21.50	71.15
Turks Island	21.35	70. 8
Abrolho, N. Point	21.40	68.40
Plate Wreck	20. 4	68.10
Coast of *Carolina, Virginia, Maryland, Pensylvania, New-Engld.* and *New-foundland.*		
Charles Town upon Ashby River	32.40	78.50

Places

Places Names.	Nor. Latit.	West Lon.
Coast of *Virginia*, &c.	D.M.	D.M.
Cape Hateras	35.10	74.25
Cape Henry	37. 0	74.30
Cape Charles	37.14	74.15
Cape Hinloper	39. 4	73.25
Long Island	40.50	70.40
New York	41. 0	72. 5
Cape Cod	42.10	67.45
Boston	42.35	68.50
Cape Sable	43.45	63.25
Island Sable	44.30	59. 5
Cape Britain	46.20	58.15
Quebeck	47.15	68.10
Bay of Breſt	52.10	55. 0
Bell Island	52. 5	54.10
Cape St. John	50. 9	52.35
Pengwin Iſle	50.15	53.10
Cape Bonaviſta	49.11	52. 3
Trinity Bay	48.27	52.15
Conception Bay	47.53	52. 0
St. John's Harbour	47.28	51.25
Bay of Bulls	47.40	51. 9
Cape Race	46.30	51 25
Cape St. Mary	47.10	53.20
Placentia	47.57	53. 0
Cape Roy		

Coaſt of *Hudſon's Bay* and *Straits*.		
Buttons Iſle	60. 5	66.50
Cape Charles	62.35	75.20

Places Names.	Nor. Latit.	West Lon.
Coaſt of *Hudſon's Bay* and *Straits*.	D.M.	D.M.
Cape Walſingham	63.15	77.40
Mansfield Iſle	62.20	80 50
Cape Jones	55. 3	79.15
Rupert's River	51.10	79.55
Albany River	52.32	84. 7
The Cubbs	54.15	82. 0
C. Henrietta Maria	55. 5	84. 2
Port Nelſon	57. 5	92.47
Cape Churchill	59. 0	92.57
C. Southampton	61.57	88.30
Shark Point	64.27	83.20
Nottingham Iſle	63.38	79.47
Q. Ann's Foreland	63.32	73.57
Reſolution Iſle	61.55	65.50
Cape Farewel	59.10	46 35

Sea-Coaſts in the *Sound* and *Baltick Sea*.		East Lon.
Maerden	58.25	9. 5
Laerwick	58.54	9. 20
Chriſtiana	59 10	9. 45
Maeſterland	57.58	11.45
Gottenberg	57.33	12.25
Elſinore	56. 0	12.32
Copenhagen	55.44	12.35
Valſteborn	55.20	12.55
Kalmer	56.40	16.40
Stockholm	59.20	18.25

Places Names.	Nor. Latit.	East Lon.
Sea-Coasts in the *Baltick.*	D.M.	D.M.
Vyburgh	60.20	29.26
Petersburgh	59.25	29.50
Narve	58 39	28.14
Revel	59. 0	24.45
Riga	56.50	24.50
Derwinda	57.20	22. 0
Coningsberg	55. 0	20.20
Dantzick	54.22	19. 0
Wisbuy in Gotland	57.37	18.50
Bornholm	55.37	14.53
Straelsound	54.45	13.20
Lubeck	54.25	11. 5
Anout	56.42	10.58
Lesou	57. 5	10.40
Scaw	57.26	10.10
Sea-Coasts from the *Naze* of *Norway* to *Arch-Angel.*		
Naze of Norway	57.50	7. 22
Northbergen	60.16	5. 40
Standland	62.10	4. 38
Dronton	64. 0	10.40
Loefort S.W. Point	67.47	9. 35
Tromsound	70.18	16. 9
Surroy	71. 5	18.40
North Cape	71.25	22. 0
Kilduyn	69.32	30.15

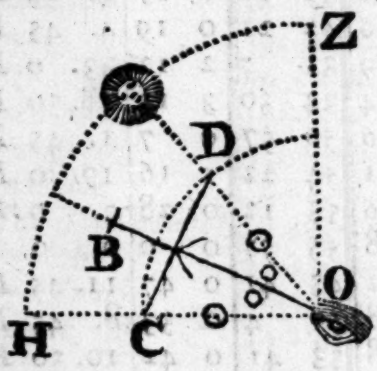
Places Names	Nor. Latit.	East Lon.
Coast of *Norway.*	D.M.	D.M.
Sweetsnose	68. 8	34.41
Cross Island	66.31	36.33
Archangel Bar.	65. 5	35.30
Coast of the Northern Isles, *Nova-Zembla, Iceland,* and *Greenland.*		
Catsnose	65.43	35.14
Cape Candenose	69.27	42.30
Fretem Borrough	69.55	62. 5
Admiralty Island	75. 5	59.50
Bear Isle	74.35	18. 5
Hope Isle	76.22	22. 0
Lees Foreland	78. 5	23.25
Helies Sound	79.15	12. 5
Halcuit Head-land	79.55	12. 0
Point Look out	76.40	16.25
Cape Cold, N. end	79. 0	10.32
Fair Foreland	79.18	10.50
Bell Sound	77.34	13.39
Horn Sound	77.23	14.20
Isles of Fero	62. 6	5. 0
Grims Island	66.51	17.45
Merch. Foreld.	63.20	14. 5
Whales Back	65.27	10. 5
Sound Royal	66.22	14.15
Bargazat Point	66.30	11.12
Halliford	64.34	24.15

A Table of the Latitudes, Bearing and Distance, Difference of Longitudes, and Difference of Meridians, from LONDON, *of several eminent Cities and Towns.*

Places Names.	Points of Bearing.	Dist.	Latit. North		Diff. of Merid.		Differ. of Long.	
		Mile	D.	M.	H.	M.	D.	M.
Antwerp	East.	248	51	10	0	17	4.	15 *E*
Amsterdam	E. b. N.	266	52	21	0	19	4.	45 *E*
Alexandria in Egypt	S. E. b. E.	2169	31	7	2	12	33.	0 *E*
Babylon	E. S. E.	2724	34	30	3	14	48.	30 *E*
Calis in France	E. b. S.	86	50	57	0	7	1.	45 *E*
Dantzick in Poland	E. N. E.	961	54	22	1	16	19.	0 *E*
Dublin in Ireland	N.W.b.W.	296	53	12	0	28	7.	0 *W*
Edinburgh in Scotl.	North	328	55	57	0	0	0.	0
Florence	S. E.	802	43	41	0	47	11.	45 *E*
Frankfort	East	448	50	4	0	33	8.	45 *E*
Hamburgh	E. N. E.	538	53	41	0	42	10.	30 *E*
Lisbon in Portugal	S. S. W.	985	38	50	0	42	10.	30 *W*
Mexico	W. b. S.	6844	20	6	6	49	102.	10 *W*
Naples	S.E.b.E.	1051	41	5	1	3	15.	45 *E*
Paris in France	S. S. E.	215	48	50	0	9	2.	15 *E*
Prague in Bohemia	East	700	50	40	0	58	14.	30 *E*
Rome	S. E. b. E.	887	41	51	0	52	13.	0 *E*
Tolodo in Spain	S. b. W.	934	39	46	0	14	3.	30 *W*
Sevil in Spain	S. b. W.	956	37	36	0	26	6.	30 *W*
Venice	E. S. E.	744	45	18	0	50	12.	30 *E*
York	North	150	54	0	0	0	0.	0

To find the Sun's Meridian Altitude or Zenith Diſtance, (conſequently the Latitude at Sea, with the Sun's Declination given) with Two Sticks only, (if you are depriv'd of your Fore-ſtaff or Quadrant.)

TAKE Two ſtrait Sticks, of any convenient Length, as OB and CD; let One, as CD, be about ⅔ the Length of the other: Divide OB into any Number of Equal Parts, as ſuppoſe 30 Parts; and each of theſe you may again Subdivide into Ten Equal Parts. Divide likewiſe the ½ of CD, into any Number of the like Equal Parts, as ſuppoſe 10; then placing the Stick CD, (with a Mortice or the like, in the Middle thereof, to move upon OB at Right Angles:) And then, if you would find the Sun's Noon Altitude, a little before 12 at Noon, take the Stick OB, and placing it to your Eye, looking to the Centre of the Sun, move the Croſs-Stick CD, nearer or farther from your Eye, till you cut the Center of the Sun with the upper Part, D, and the Horizon HO, with the lower Part, C: Then, when the Sun is in the Meridian, admit you have 20 Parts of the Staff from O to B; and the ½ Length of the Croſs-Stick CB or BD, 10 Parts; we may then find the *Hypo* OC = OD, and Angle COB, the Half of the Sun's Altitude; by the ſame Method, as Caſe 6th, Method 4. of *Plain Sailing*, i.e.



20 X 20 = 400 and 10 X 10 = 100.

$\sqrt{\text{q OB} + \text{q BC}} = \text{OC} = 22.3$, and OC 22.3 + ½OB = 32.3 Z.

400 + 100

As OC + ½ OB .. BC :: 86 .. Angle COB,

32, 3 —— 10 — 86 —— 26°. 36′. which Doubled is 53°. 12′. the Sun's Meridian Altitude requir'd.

Laſtly,

Laſtly, 90°. 00'. — 53°. 12'. = 36°. 38'. Sun's Zenith Diſt. The Latitude may be found by the foregoing Rules of working an Obſervation.

(N°. 28.) *To find the Sun's greateſt Declination.*

RULE.

OBſerve the Sun's greateſt and leaſt Meridian Altitude, on the Longeſt and Shorteſt Days of the Year; Half the Difference of theſe Altitudes, is the greateſt Declination of the Sun.

Example.

SUPPOSE at *London*, *Anno* 1724.

On { *June* / *Decemb.* }	the { 11th. / 11th. }	the ☉'s Merid. Altit. is {	61°. 58'.	
			14 : 58	
Their Diff. is the Diſt. of the Tropicks			47 : 00	
The Half whereof is the ☉'s greateſt Declination			23 : 30	

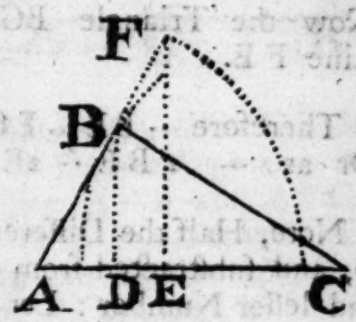
The Three Propoſitions or Theorems in Plain Trigonometry, (*P.* 28. and 29.) *demonſtrated.*

THEOREM or PROP. I.

IN all Plain Triangles, the Sides are Proportional to the Sines of their Oppoſite Angles, & *contrà*.

Conſtruction.

Produce the leſſer Side A B, to F; make A F = to B C, and let fall the Perpendiculars F E, B D, upon the Side A C, produc'd if need be.



Demonſtration.

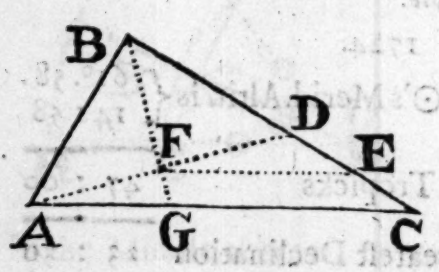
Then will F E be the Sine of the Angle at A, and B D the the Sine of the Angle at C, to the

the Radius BC = AF. Now the Triangles ABD, AFE, are Similar and Proportional (by *Euclid* 4. 6.) Therefore, as AF = BC .. AB :: FE .. BD, *i. e.* So is the Sine of the Angle A, to the Sine of the Angle C. *Q. E. D.*

THEOREM II.

IN all Plain Triangles, as the Sum of any Two Sides is to their Difference; ſo is the Tangent of Half the Sum of their Oppoſite Angles, to the Tangent of Half their Difference; or of an Arch which added to the Half Sum gives the Greater, or ſubſtracted, gives the Leſſer of the Two Angles requir'd.

Conſtruction.



In the Triangle ABC, make BD = BA, and draw the Line AD.

Let fall the Perpendicular BF, upon the Line AD, which will Biſect AD in F; alſo draw FE parallel to AC, which will Biſect DC, the Difference of the Two leſſer Sides in E.

Demonſtration.

The Angle BAF is Half the Sum of the Angles BAC; and C, and FAG, Half their Difference.--- Now if AF be made the Radius of a Circle, BF will be the Tangent of Half the Sum, and FG of the Half Difference. Now the Triangle BGC, is cut proportionably by the Line FE.

Therefore --- BE .. EC :: BF .. FG
Or as --- 2BE .. 2EC :: BF .. FG } *Q. E. D.*

Note, Half the Difference of any Two Numbers, added to, and ſubſtracted from their Half Sum, gives the greater and leſſer Number: Let the Numbers be 12 and 8.

Now

Now $12 + 8 = 20$

And $12 - 8 = \frac{4}{2} = 2$ and $\frac{1}{2}$ X. $\left.\begin{array}{l} \frac{20}{2} = 10,\frac{1}{2}\text{ Z.} \\ \end{array}\right\}$ and $\begin{array}{l} 10 + 2 = 12 \\ 10 - 2 = 8 \end{array}$

The $\left\{\begin{array}{l}\text{greater}\\ \text{leſſer}\end{array}\right\}$ Number; and conſequently, the Half Diff. added to, or ſubſtracted from the Half Sum of the Angles, gives the greater or leſſer Angle requir'd.

THEOREM III.

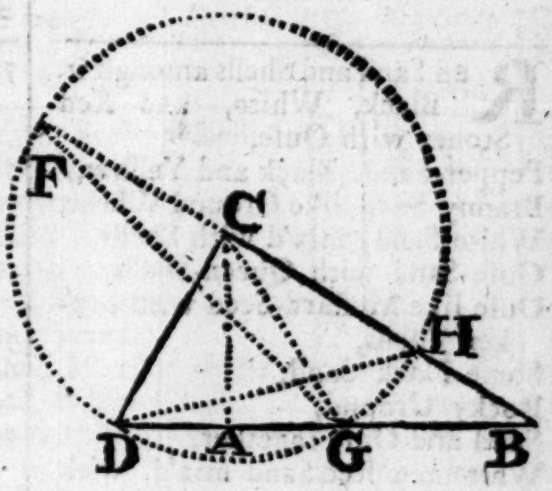
IN all Plain Triangles, as the Baſe (or Longeſt Side) is to the Sum of the other Two Sides; ſo is the Difference of thoſe Sides, to the Difference of the Segments of the Baſe, (made by a Perpendicular let fall from the greater Angle of the ſaid Baſe.)

Conſtruction.

In the Triangle DBC, with the Radius CD, deſcribe the Circle DFH.

Extend, or produce BC to F, and join FG, DH, and CG.

Let fall the Perpendicular CA.



Demonſtration.

Then is BF = Sum of the Sides, CD and CB; and HB is = their Difference; alſo GB is the Difference between AB and AD; the Segments of DB the Baſe: And the Triangles HDB and BFG, are Similar, (or like) becauſe of their Equal Angles, D and F; and the Arch GH being the Double Meaſure of them both: Alſo the Angle at B, common to both the Triangles, HDB and BGF. Therefore,

Proportionably;

As BD .. BF :: HB .. GB.

That is, as DB the Baſe, is to FB, the Sum of the Sides, ſo is HB the Difference the Sides CB and CD, to GB, the Difference of the Segments of the Baſe. *Q. E. D.*

Then the Half GB $\begin{cases} +BD = AB \\ -BD = AD \end{cases}$ The Baſe of the Right Angled Triangle $\begin{cases} BAC. \\ DAC. \end{cases}$

(N°. 29.) ***A Table of the Soundings coming into the Britiſh Channel; the Quality of the Ground brought up by the Tallow on the Lead; with the Bearings and Diſtance of*** **Silly, *the* Lizard, *&c.***

Quality of the Ground brought up by the Lead.	Depth.	Bearings *Silly.*	Diſt.	Latit. D.	Latit. M.
Red Sand and Shells amongſt it, Black, White, and Red Stones with Ouſe,	77	*N. N. W.*	33	48	52
Pepper-Sand, Black and Yellow,	72	*E. b. N.*	25	49	50
Branny Sand, like Ground Wheat,	72	*E. b. N.*	15	48	50
White Sand, mix'd with Shells,	50	*South.*	5	50	20
Ouſe Sand with Queen-Shells,	45	*S. S. E.*	5	50	12
Ouſe like Muſtard-Seed with broken Shells,	58	*E. b. S.*	8	50	12
Some Black Sand,	72	*E. b. N.*	7	49	15
Rocky Ground,	60	*E. N. E.*	7	49	15
Sand and Ouſe together,	80	*E. N. E.*	20	49	15
White and Red Sand mix'd, with Shells,	85	*N.E.b.E.*	22	49	10
White Sand, with Ouſe and Nits,	55	*N.E.b.E.*	10	49	20
Branny Sand, with White and Red Shells,	100	*N.E.b.E.*	50	49	50
Black Sand,	64	*N.E.b.E.*	25	49	50
Branny Sand, with ſome Pieces of Shells,	48	*N.E.b.E.*	6	49	10
Branny Sand, Herring-Bones, ſmall Stones,	65	*N.E.b.E.*	13	49	43
	65	*N. E.*	10	49	40

Quality

Quality of the Ground brought up by the Lead.	Depth.	Bearings *Silly.*	Dist.	Latit. D.	Latit. M.
Small Red Sand,	57	*N.E.*b.*N.*	10	49	20
Broken Shells, with White and Red Sand,	65	*North.*	12	49	15
White Sand on the Eaſt Part of the Bank,	65	*North.*	10	49	47
Branny Sand, with Black and broken Shells,	50	*N. W.*	4	50	10
Stony Ground,	60	*N. W.*	7	49	47
Red and Black Sand, with gliſtering Shells,	61	*N.W.*b.*N.*	4	50	25
Fine White Sand, with a little Ouſe,	63	*W.*b.*N.*	13	50	25
Red and Black Sand with gliſtering Shells,	66	*Weſt*	21	50	8
Fine White Sand, with gliſtering Shells,	75	*W.*b.*S.*	31	49	50

Quality of the Ground brought up by the Lead.	Depth.	Bearings *Lizard.*	Dist.
Marſhy-Shells, and ſome Scollop-ſhells,	48	*N. E.*	6½
Marſhy-Shells and Hakes-Teeth,	53	*N.E.*b.*N.*	10
Marſhy-Shells, like Oatmeal Husks,	50	*N. N. E.*	9
Marſhy-Shells and Hakes Teeth,	58	*N.* b. *E.*	15
Stones as big as Beans, ſo 4 l. off,	39	*North.*	1
Grey Sand like Oatmeal Flower,	45	*N. W.*	5
Marſhy Shells and ſmall Stones,	43	*N. W..*	3
Small Slingly Stones, and Marſhy-Shells,	47	*W. N. W.*	3½
Fine Marſhy-Shells and White Stones,	40	*W.* b. *N.*	4
Black gravelly Ground with ſmall Stones,	41	*W.* b. *S.*	30
Scollop-Shells,	57	*N.E.*b.*E.*	12
Great Stones and rough Ground,	44	*N.E.*b.*E.*	4
		Eddyſtone	
Dirty Brown Sand and Hakes Teeth,	35	*North.*	½
Dirty Brown Sand,	34	*Weſt.*	2
Fine Sand, and within this 28 and 30 Fath.	26	*South.*	1

Quality

Quality of the Ground brought up by the Lead.	Depth.	Bearings.	Dist.
		Start.	
Like the Duſt of a Grindſtone, with Hakes Teeth and Shells,	40	*N.E.* b *E.N.*	8½
	43	*N.W.* b. *W.*	4½
Gravelly Sand. ſmall Stones, and Shells,	38	*N.W.* b. *N.*	3
Reddiſh Shells maſhed, as if beaten in a Mortar, White Sand and Scollop-ſhells,	38	*N.* b *W.W.*	12
	42	*N.W.* b. *W.*	14
		Portland.	
Small ſhingly Stones, as big as Peaſe,	35	*N.E.* b. *E.*	8
Streamy Ground, with ſmall Stones,	40	*North.*	8
The ſame, with ſome Black Sands,	33	*N.* b. *E.*	5½
Fine Sand, with Scollop-ſhells,	41	*N.E.* b. *N.*	11
Fine Sand, Scollop-ſhells, and ſmall Stones,	40	*N.N.E.*	8
Shingly Ground,	27	*N.E.* b. *E.*	2½
Small Stones,	20	*W.N.W.*	2½
		Needles.	
Great Shingly Ground,	17	*N.E.* b. *E.*	2
Small Shingly Ground,	19	*N.E.* ½ *E.*	2½
Rocky Ground,	13	*N. E.*	2
		Iſle Wight.	
All the Ground from the *Albions*, to to the Eaſt End of the *Wight*, is Chalky, and Brown Sand.	20	*N.* b. *W.*	3½
	21	*E.* b. *N.*	4
	18	*N.* b. *E.*	3
		Dunnoſe.	
Rough Ground, with ſome big Stones,	16	*W.* b. *S.*	4
A kind of ſandy Fiſhing-Ground,	21	*Weſt.*	4
Fiſhing-Ground, ſomewhat Red with Stones as big as Peaſe, and ſome as big as Beans.	33	*W N.W.*	8
	26	*N.* b. *W.*	6

ERRATA.

IN *the Tables, Page* 2. *Line* 7. *read* ☽ Eclipſ. Octob. 21. *and l.* 25. *ibid. r.* ☽ Eclipſ. Feb. 14. *p.* 21. *and* 22. *running Title, r.* Logarithmetick; *p.* 23. *for* Log. Line *r.* Log. Sine. *Appendix, p.* 21. *l.* 22. *r.* Wine Gallons; *p.* 24. *l.* 31. *r.* alſo if.

APPEN-

APPENDIX.

A Collection of ſundry Pleaſant and Critical Queſtions in NAVIGATION; deſign'd for the Improvement and Diverſion of the Learner, at his ſpare Hours.

In Plain Sailing.

QUESTION I.

ADmit a Ship ſails from a certain Port, between the South and Weſt, and finds the Diſtance Run and *x*'s. Lat. in one Sum 160 m. and her Departure 60 m. What's her Courſe, Diſt. and *x*. Lat. ſeverally?

QUEST. II. Suppoſe a Ship ſails from the Tropick of Cancer between the South and Eaſt, and finds her Lat. by Obſervation to be 12°. 24'. N. and her Diſtance and Departure together is 666 Leagues: I demand the Courſe ſteer'd, with her Diſtance and Departure?

QUEST. III. Admit a Ship ſails from a Port in the S.W. Quarter of the Compaſs 120 m. until the Sum of her *x*. Lat. and Departure be 160 m. What Courſe hath ſhe ſteer'd, and what Southing and Weſting hath ſhe made?

QUEST. IV. Suppoſe a Ship ſails from the Lat. of 50°. 00'. S. N.E. by N. till her Diſtance, *x*. Lat. and Departure, in one Sum is 600 Leagues: I demand

mand them ſeverally, with the Lat. arrived into?

QUEST. V. If a Ship ſails S.W.b.S. from the Lat. of 46°. 27′. N. until her Diſtance is 160 Miles more than her *x*'s. Lat. I demand them ſeverally?

QUEST. VI. If a Ship ſails North-Eaſterly 600 m. and and then her Departure is 120 m. more than her *x*. Lat. What's her True Courſe, *x*. Lat. and Departure?

QUEST. VII. Suppoſe a Ship ſails W.S.W. from the Lat. of 40°. 20′. N. and then finds her Diſtance to be 90 m. more than her Departure: I demand the wanting Particulars?

QUEST. VIII. Admit a Ship ſails from the Lizard in the S.W. Quarter, 153 m. then finds her *x*'s. Lat. to exceed her Departure by 30 m. I demand her direct Courſe, Departure, and Lat. come into?

QUEST. IX. Suppoſe a Ship ſails from the Lat. of 5°. 55′. North, between the South and Eaſt, (but more Southerly than Eaſterly,) till her Diſtance, *x*. Lat. and Departure, together was 600 m. I demand them ſeverally, with the Courſe ſteer'd, and Lat arriv'd in?

QUEST. X. If a Ship ſail South Weſterly, until her Di ſtance is 200 m. more tha the *x*. Lat. and the *x*. Lat. i 96 more than her Departure I demand them ſeverally, wit the direct Courſe ſteer'd?

QUEST. XI. Suppoſe a Shi ſails from the Equator, be tween the North and Eaſt, an for every 50 Leagues ſhe runs ſhe differs her Lat. 40 L. an thus ſhe continued her ſailing till her Departure was 80 L I demand the Ship's direct Courſe, and Diſtance, and Lat ſhe is come into?

QUEST. XII. Admit a Ship ſails from the Lat. 3°. 33′. S between the South and Weſt and for every 7 Leagues ſhe runs, ſhe departs from the Meridian 4 Leagues; and ſo ſhe continues, till ſhe arrives in the Lat. of 17°. 39′. I demand her direct Courſe, Diſtance and Departure?

QUEST. XIII. Admit a Ship ſails from a Port, in the Lat. 20°. North, between the South and Eaſt, and for every 3 Miles ſhe differs in Lat. ſhe departs from the Meridian 4 Miles; and thus ſhe continues till her Diſtance run is 555 Leagues. I demand

and the wanting Particulars?

QUEST. XIV. Admit a Ship ſails from a Port, in Lat. 2°. 55′. North, between the South and Weſt, till her Diſtance is 342 Leagues more than her Departure, and 145 Leagues more than her *x*. Lat. I demand her Diſtance, Departure, Courſe, and Lat. come into?

QUEST. XV. A Maſter of a Ship, ſailing towards the Eaſt, hath forgot his Courſe; yet thus much he knows, that if he had ſail'd upon his true Courſe 108 Leagues, he ſhould have rais'd the Pole 2°. 51′. and have been as much more diſtant from the Meridian than now he is; and alſo ſhould have been 57 m. more Northerly. I demand the Courſe, Diſtance and Departure?

QUEST. XVI. Admit a Ship ſails from an Iſland, in Lat. 4°. South, N.E.b.N. until ſhe comes into the Lat. 4°. North. I demand her Diſtance and Departure to and from the Equator?

QUEST. XVII. Suppoſe Two Ships ſail from the Tropick of Cancer, the firſt S.W. and the other S.E. the firſt Ship ſail'd 665 Leagues, and the other ſail'd to the Equator. I demand the Reſt?

QUEST. XVIII. Admit four Ships ſail from one Port on the Equator. The Firſt ſteer'd N.W. the Second N.E. till they came to the Tropick of Cancer: The Third ſail'd S.E. and the Fourth S.W. till they arriv'd at the Tropick of Capricorn, and were then aſunder 940 Leagues. I demand each Ship's Diſtance and Departure?

QUEST. XIX. Suppoſe a Maſter of a Ship, coming to an Anchor, and would Moore his Ship, having 95 Fathom to his ſmall Bower Cable's Service; and found 35 Fathom of Water, the Buoy bearing up and down. I demand how much Beſt Bower Cable he muſt veer out, to bring his Small Bower Service in the Hawſe, when the Ship is hove up again and Moor'd?

QUEST. XX. Suppoſe that Three Ships are all bound to one Port; One Ship is in the Lat. of 20°. North, the Second in Lat. 30°. North, and the Third in Lat. 40°. North; the Port lies in the Lat. of 50°. N. and they all ſail'd one Diſtance, *viz.* 740 Leagues. I demand their ſeveral Courſes and Departures?

QUEST. XXI. There were Three Flags ſet ſail, in the *Albemarle*, *Union* and *Namur*, from Port *Mahon*, in Lat. 39°. 55′ North; with Four Ships of War more, *viz.* the *Cornwal*, *Orford*, *Revenge*, and *Torbay*: The *Albemarle* ſailed N. the *Union* ſail'd N.E.b.N. and *Namur* Eaſt, each 85 Leagues. The *Cornwal* ſail'd N.E.b.N. until ſhe made a Tangent with the *Albemarle*; and the *Orford* ſail'd alſo N.E.b.N. until ſhe made a Tangent with the *Namur*; and the *Torbay* ſail'd North, the *Revenge* Eaſt, until they made Sines with the *Union*. Now I demand each Ship's Diſtance, *x*. Lat. and Departure; the Flags being the Radius's?

QUEST. XXII. Two Ships ſail from an Iſland in the Latitude of 30°. 59′. North, and they are bound to the Eaſtward: In their ſailing they make an Angle of 112°. 30′. and One comes into the Lat. of 29°. North, and then both are under one Meridian. I demand each Ship's Diſtance and Departure?

QUEST. XXIII. There are Two Ports, A and C, both in the Lat. of 45°. North: A Ship at the Weſtermoſt at A, ſails betwixt the North and Eaſt to another Port at B, 45 Miles; and then, altering her Courſe 90°. or 8 Points, ſails a certain Diſtance between the South and Eaſt, and arrives at the other Port, C; and her Departure or Eaſting from the Second Port, B, to the Third Port, C, is 48 m. I demand what was the Ship's Eaſting from the Firſt Port A, to the Port B; and what Lat. the Port B lies in: Alſo, her Courſe and Diſtance from the Second Port at B, to the Third Port at C?

QUEST. XXIV. Suppoſe a Ship ſet ſail from a Port at B, in the Lat. of 44°. North; ſhe runs a certain Diſtance between the North and Weſt, and then arrives at another Port at C, in the Lat. of 44°. 18′. North; from the Port C, ſhe alters her Courſe 90°. and ſails between the South and Weſt a certain Diſtance, which exceeds her former Diſtance ſailed by 7⅓ m. and then arrives at another Port, A, in the ſame Lat. with the Port ſail'd from, B. I demand the Diſtance aſunder of the Firſt and Third Ports, B and A: Alſo the Diſtance of the Ports A and C, and C and B; with the Firſt and Second Courſes and Departures, D B and D A?

QUEST. XXV. Admit Two Ports, A and B, lie both in the Lat. of 30°. North, a Ship ſails from A, between the North and Eaſt, a certain Diſtance, and then arrives at ano-

another Port, D, in the Lat. of 30°. 18'. North; and then altering her Courſe 90°. ſails between the South and Eaſt a certain Diſtance to another Port, B. I demand her Courſe, Diſtance, and Departure from A to D; and her Courſe, Diſtance, and Departure from D to B?

QUEST. XXVI. Suppoſe a Ship ſails from a Port at A, between the North and Eaſt, to a Port C, in the Lat. of 50°. North, and then the Sum of her Diſtance and Departure is 54 L. from the Port C; ſhe alters her Courſe, 90°. and ſails in the South-Eaſt Quarter of the Compaſs, and arrives at another Port, B, in the ſame Latitude with the Port A, and finds her Second Diſtance, Run and Departure, in one Sum 35, 7. L. I demand her Courſe, Diſtance, and Departure from A to C, and from C to B; and the Latitude of the Ports A and B, and their Diſtance aſunder?

QUEST. XXVII. There are Three Iſlands, A B and C, in Form of a Right Angled Triangle; that is, the Iſland B, bears of C due South; A bears from B, due Weſt; and ſuppoſe a Ship ſailing from C to A, between the South and Weſt, and that the Sum of her Diſtance, *x*. Lat. and Departure, is found to be 90 L. and the Area or Content of this Right Angled Triangle the Ship hath made, is 330 L. I demand her Courſe, Diſtance, *x*. Lat. and Departure ſeverally? Or, which is the ſame, the Diſtance of each Iſland from each other?

QUEST. XXVIII. A Ship ſails between the South and Weſt, till the Sum of her *x*. Lat. and Departure is 70 m. and the Sum of her Diſtance Run and Area of the Triangle is 650 m. (or the Difference of the Area and Diſtance is 550 m.) I demand the Diſtance, Difference, Lat. and Courſe ſteer'd?

QUEST. XXIX. There is a Round Sea or Lake, of an unknown Diameter, upon which the Wind is obſerv'd to blow always one Way, but upon what Point of the Compaſs is unknown: Upon the Coaſt hereof are Two Ports, A and B, Diametrically oppoſite to each other; ſo ſituate, that the Trade-Wind blowing there, will be ſomewhere upon the Larboard Quarter, during their ſailing from A to B; but how many Points abaft the Beam, is unknown; the Courſe and Diſtance between the Two Ports, is alſo unknown. —— A Ship at A, intending for B, was no ſooner got out of the Harbour, but he was aſſaulted by Pirates; who, after a long Conflict, carried away his Main-Maſt, Mizzen-Maſt, Fore-

Fore-Top-Maſt, and alſo his Rudder; and came Aboard to Plunder, taking away his Goods, Books, Inſtruments, Charts, Compaſſes, *&c.* Being left in this Diſtreſs, he ſets his Fore-Sail, and having no Rudder, nor any more Sail to command her with, he let her drive right before the Wind, till at laſt ſhe drove a-ſhore in a little Creek, altogether unknown to the Maſter; nor did he know the Courſe and Diſtance from this Creek, either to the Port ſailed from, or to the Port bound for: However, here he got ſuch Maſts and Sails as he had occaſion for, with a Rudder, and all that was neceſſary to the Working of the Ship; but could get no Books, Charts, Inſtruments or Compaſs. I demand what Means he muſt uſe, to guide the Ship to the Port at B?

QUEST. XXX. There is a Round Lake, whoſe Diameter is 360 m. upon the Coaſt of which lie Two Ports, A and B, whoſe neareſt Diſtance in a ſtrait Line, is 120 m. but their Bearing or Situation is not known: A Ship at A, ſails away Weſt, a certain Diſtance, and then arrives at another Port at O, whoſe Bearing and Diſtance both from A and B, are unknown; and at the Port at O, he takes in Goods for B. I demand what Courſe he muſt ſteer, to find the Port at B?

QUEST. XXXI. Two Ships of War, the *Suffolk* and *Kent*, ſail'd from *Flores* in Lat. 39°. 39'. North, 5 Points aſunder: The *Suffolk* ſail'd between the North and Weſt, and made her Departure 88 m. and the *Kent* ſailed North-Eaſterly, and made her Departure 60 m. and then they were both in one Lat. I demand their Courſes, Diſtances, and *x* Latitudes?

In Oblique Plain-Sailing.

QUESTION I.

I Being in a Ship, bound to an Iſland, and know neither the Courſe, Diſtance, *x.* Lat. nor Departure; but I heard the Maſter tell the Mate, that if he would ſail N.W.b.N. 92 Leagues, then the Iſland would bear South, Diſtance 180 Leagues. The Courſe and Diſtance of the Iſland, at firſt ſetting out is requir'd.

QUEST. II. Suppoſe a Merchant Ship in the Lat. 45°.30'. North,

North, falls into the Hands of Pirates, who take away his Sea-Compaſs; after which, he ſails as directly as he can 67 Leagues between the South and Weſt; and at the End of Two Days meets a Ship of War, who alſo had been the Day before in the Lat. 45°.30'. North, and had ſailed thence, S.E.b.S. 39 Leagues; now the Merchant-Ship left thoſe Pirates to and fro, where they robb'd him; and the Man of War being deſirous to ſpeak with thoſe Pirates, I demand what Courſe he muſt ſhape to meet them?

QUEST. III. Coaſting along Shoar, I ſaw Two Capes of Land; the Firſt did bear N. the Second did bear W.N.W. Then I ſtood away N.W.b.N. 9 m. until the Firſt did bear from me E.b.S. and the Second S.b.E. The Bearing and Diſtance of them is requir'd?

QUEST. IV. Suppoſe a Ship ſailing N.W. Two Iſlands appear in ſight, one bears W.N.W. the other N. of the Ship; and when the Ship had ſail'd 6 m. farther, the firſt bears W.b.S. and the other N.E. their Bearing and Diſtance is requir'd?

QUEST. V. Three Ships ſail from one Port; the Firſt ſails S.W.b.W. the Second, W.b.S. $\frac{1}{2}$W. and the Third, N.W.b.W. 8 Miles. Then the Firſt bears from the Third, S.b.W. the Second bears from the Third S.S.E. The Firſt and Second Ship's Diſtance ſail'd, and their Bearing and Diſtance from each other, is requir'd?

QUEST. VI. Admit ſailing along Shore, I ſee two Head-Lands, the Eaſtermoſt bears N.N.E. and the Weſtermoſt N.W. from me; at the ſame time, an Iſland bears South: Then, after I ſail'd Weſt 8 m. the Firſt did bear N.E.b.E. $\frac{1}{2}$E. the Second N.N.E. and the Iſland E.S.E. from me. The Bearing and Diſtance of theſe Places from each other is requir'd?

QUEST. VII. A Fleet of Ships, with Four Men of War, with the Wind at W.b.S. ſails away S.E. 3 Miles an Hour, till hearing of ſome Pirates to the Northward of them, the Commadore ſends out a Man of War a Cruiſing, who ſails due North 7 Miles an Hour, for the ſpace of 11 Hours; and finding the Pirate, (after an Hour's Conflict) took him; the Fleet all the while ſailing S.E 3 Miles an Hour. Now I demand what Courſe the Man of War and the Pirate muſt ſail, that they may juſt fall in with the Fleet, without altering their Courſe; ſuppoſing they ſail 7 Miles an Hour?

QUEST.

QUEST. VIII. Coaſting along Shore, I ſet Two Head Lands; one bears N.b.W. the other N.E.b.E. and a Buoy bears N.E.b.N. At the ſame time I ſaw Two Iſlands; the one bears S.S.W.$\frac{1}{4}$W. and the other E.S.E. and a Rock S.E. Then I ſailed Eaſt 100 Miles, and the firſt Head-Land bore N.W.b.W. the ſecond N.$\frac{1}{4}$E. and the Buoy N.W.$\frac{1}{2}$W. then the firſt Iſland bears W.S.W. and the other Iſland, S.b.E.$\frac{1}{4}$E. and the Rock S.W.b.W. I demand their Bearing and Diſtance from each other?

QUEST. IX. Two Men of War, the *Breda* and *Ruby*, ſail'd in ſearch of Pirates, and took their Departure from the *Grand Canary* in Lat. 28°. N. both ſailing one Courſe, South-Weſterly 69 m. and came up with the Pirates, and Engag'd them, *viz.* Three Pirates, Two of which were taken by the *Breda*; and the Third ran away, and was perſued by the *Ruby* on the ſame Courſe, until her Departure from the *Grand Canary* was 77 Miles, and then took the Third Pirate. Now I demand the *Ruby*'s Courſe, to join with the *Breda* again, and her Diſtance from the *Grand Canary*; and alſo in what Lat. ſhe took the Pirate?

QUEST. X. Suppoſe the Wind at South, and a Ship of War in ſight of a Head-Land, bearing N.E. 7 Leagues, was ordered by the Commadore to Weather it, ſo as to reach an Iſland 3 Leagues to Windward of the ſaid Head-Land, at Two Boards, having then her Starboard Tacks Aboard; and can make her Way good within 6 Points of the Wind. I demand how far ſhe muſt run upon that Tack, before ſhe goes about; with her Larboard Tacks, to bring the Head-Land 3 Leagues to Leeward?

QUEST. XI. Two Ships ſail from one Port; the Firſt Ship ſails due South, and the other W.S.W. more than the Firſt 39 Leagues; and then they were 76 Leagues aſunder. I demand how many Leagues each Ship had then ſailed?

QUEST. XII. Two Ships ſail'd from one Port; the firſt Ship ſail'd S.S.W. a certain Diſtance; then altering her Courſe, ſhe ſail'd due Weſt 92 Leagues: The ſecond Ship ſailed 120 Leagues, and meets with the Firſt. I demand the ſecond Ship's Courſe, and how many Leagues the firſt Ship ſailed upon the S.S.W. Courſe?

QUEST. XIII. Two Ship's ſail from two ſeveral Ports in one Latitude, and 90 Leagues aſunder; the Weſtermoſt Ship ſails N.E.b.E. the Eaſtermoſt Ship

Ship ſails upon ſome Point between the N. and W. and then they meet. If the Diſtance Run, of both theſe Ships be together 136 l. I demand them ſeverally, and the Eaſtermoſt Ship's Courſe?

QUEST. XIV. A Ship at an Iſland, in the Lat. 47°. 56'. N. ſails to another Iſland W.S.W. then to a Port N.b.E. until the firſt Iſland bears from her E.S.E. Now her Diſt. ſailed in both Courſes, with her Diſt. to the firſt Iſland together is 342 m. I demand her Diſt. ſailed on each Courſe, with her Diſt. from the firſt Iſland?

QUEST. XV. Three Ships are at Three Ports; the Eaſtermoſt Ship is diſtant from the Northermoſt 75 m. and bears S.E.b.S. and the Weſtermoſt is diſtant from the Northermoſt 85 m. and beareth S.S.W. They are all bound to an Iſland, that is at an equal Diſtance from them. I demand each Ship's Courſe and Diſt. to the ſaid Iſland?

QUEST. XVI. Admit Two Ships at one and the ſame Inſtant of Time, had ſailed from one Port; the one ſails N.W.b.N. 61. a Watch, and the other ſails N.E. 81. in a Watch; and they arriv'd at Two ſeveral Ports at one and the ſame Time, the Ports being 158 l. aſunder. I demand each Ship's Diſtance ſail'd, the Bearing of theſe Two Ports, and the Time they were ſailing to them?

QUEST. XVII. Admit a Ship ſails from the *Pico* of *Fyal*, firſt N.E.b.E. ¼E. then N.W. ¼W. then S. and ſo return'd again to *Fyal*; having ſailed in all 138 l. I demand how many Leagues ſhe ſailed upon each Courſe?

QUEST. XVIII. Two Ships in the ſame Lat. Diſt. 600 m. the firſt ſails N. Eaſterly, the ſecond ſails N. Weſterly, and they meet; and at their meeting they make an Angle of 102°. 10'. and the firſt Ship had ſailed 162 m. more than the other. I demand each Ship's Courſe and Diſtance?

QUEST. XIX. Admit Two Ships ſet ſail from one Port; one ſails N.N.W. the other ſails N.W.b.W. to two Iſlands, bearing off one another N.E.b.E. and S.W.bW. Diſt. 80 l. I demand the Diſt. each Ship muſt ſail to theſe Iſlands?

QUEST. XX. Suppoſe a Ship ſails N. a certain Diſt. then E.N.E. 80 m. and S.E. a certain Diſt. laſtly, S.W.b.S. 160 m. and then is found in the firſt Place ſhe ſailed from. I demand how many Miles ſhe ſailed N. and S.E.?

QUEST. XXI. Admit a Ship at D, to ſpie Three Head-Lands A, B, C; from A to B is 70 l. from B to C is 60 l. from C to A, is 50 Leagues: C bears from the Ship N. A, N.b.E. ¼E. and B, N.N.E. I demand the Diſt. the Ship was from theſe three Head-Lands, A, B and C, and the Bearings of each from one another?

QUEST. XXII. Admit I ſee Sixteen Iſlands, each being 9 m. diſtant from me; and the Firſt did bear off me E. the ſecond E.N.E. the Third N.E. the Fourth N.N.E. the Fifth N. the Sixth N.N.W. the Seventh N.W. the Eighth W.N.W. the Ninth W. the Tenth W.S.W. the Eleventh S.W. the Twelfth S.S.W. the Thirteenth S. the Fourteenth S.S.E, the Fifteenth S.E. the Sixteenth E.S.E. The Bearings and Diſtance of theſe Iſlands aſunder is requir'd?

QUESTION XXIII.

Three Ships ſail'd from a certain Port to Sea,
The other Ports whoſe Latitude agree:
Fifty five Leagues the firſt ſail'd, South his Coaſt;
T'other to Coaſts unknown, 'twixt South and Weſt;
Till each arriv'd in his true diff'rent Place;
And they aſunder Leagues Fifty ſeven juſt was:
Angle 38°. made; whence they begun.
Pray tell me what's the Courſe and Diſtance Run?

QUESTION XXIV.

From *Edyſtone*, viewing the Neighb'ring Shore,
And willing to know how far it is o'er,
To Three Ports within ſight; their Diſtances are known
From each other, as here under I've ſhown:
I thought the beſt I could do was to try,
Which way from the Rock thoſe Three Places lie.
This I have done, and it is noted here:
Pray what will the Three Diſtances appear?

The Diſt. from { *Plymouth* to *Lizard*, 60 / *Lizard* to *Start Point*, 70 / *Start Point* to *Plymouth*, 20 } Miles.

{ *Plymouth* / *Lizard* / *Start Point* } bears from *Edyſtone* Rock { North. / W.S.W. / E.b.N. }

In

In Traverſe,

Various Queſtions, of Diverſe Figures; as of a Houſe, Church, Fort, Anchor, Caſtle, True Lovers Knot, *&c.* Ornamental to the Learner's Book.

QUESTION I.

A Ship bound to Cruiſe from an Iſland in the Lat. of 30°. 10'. *N.* ſteers away theſe ſeveral Courſes, *viz.* *N.* 40 m. *N.E.* 50 m. *S.E.* 50 m. *N.* 70 m. *E.* 12 m. *S.* 70 m. *N.E.* 50 m. *S.E.* 50 m. I demand her *x.* Lat. Dep. Courſe, and Diſt. made from the Iſland?

QUEST. II. A Ship meeting with contrary Winds, ſails as follows, *viz.* *N.* 40 m. *N.b.E.* 60 m. *S.b.E.* 60 m. *N.b.E.* 80 m. *S.b.E.* 80 m. *N.b.E.* 100 m. *S.b.E.* 100 m. *N.b.E.* 80 m. *S.b.E.* 80 m. *N.b.E.* 60 m. *S.b.E.* 60 m. I demand the reſt?

QUEST. III. A Ship ſails theſe Courſes, *viz.* *N.* 50 m. *E.* 20 m. *S.* 15 m. *E.* 20 m. *N.* 15 m. *E.* 15 m. *N.* 30 m. *N.b.E.* 60 m. *S.b.E.* 60 m. *S.* 30 m. *E.* 15 m. *S.* 15 m. *E.* 20 m. *N.* 15 m. *E.* 20 m. I demand, *&c.*

QUEST. IV. Admit a Ship in Lat. 47°. 15'. *N.* is forced by contrary Winds to ſail as follows, *viz.* *S.W.b.S.* 82 m. *N.* 23 m. *W.* 28 m. *N.N.E.*$\frac{1}{2}$*E.* 30 m. *E.* 13 m. *N.* 38 m. *W.* 16 m. *N.W.b.N.*$\frac{1}{2}$*N.* 29 m. *E.* 31 m. *N.* 34 m. *S.E.b.E.*$\frac{1}{4}$*E.* 33 m. *S.* 17 m. *E.* 34 m. *N.* 17 m. *E.N.E.*$\frac{1}{2}$*N.* 31 m. *S.* 34 m. *E.* 31 m. *S.S.W.*$\frac{3}{4}$*W.* 30 m. *W.* 16 m. *S.* 38 m. *E.* 16 m. *S.S.E.*$\frac{1}{4}$*E.* 30 m. What Lat. is ſhe come into, and what's her Departure, Direct Courſe, and Diſt.?

QUEST. V. Suppoſe a Ship from the Lat. 45° *N.* ſails theſe Courſes, *viz.* *S.E.b.S.* 29 m. *N.N.E.* 10 m. *E.S.E.* 50 m. *E.N.E.* 50 m. *S.S.E.* 10 m. *N.E.b.N.* 29 m. *W.* 25 m. *S.S.E.* 10 m. *W.S.W.*$\frac{1}{2}$*W.* 42 m. *N.* 115 m. *E*$\frac{1}{2}$*N.* 62 m. *N.* 7 m. *W.* 62 m. *N.* 10 m. *W.* 9 m. *S.* 10 m. *W.* 62 m. *S.* 7 m. *E.*$\frac{1}{2}$*S.* 62 m. *S.* 115 m. *W.N.W.*$\frac{1}{2}$*W.* 42 m. *N.N.E.* 10 m. Requir'd the reſt?

QUEST. VI. Admit a Ship in the *N.* Lat. 36°. 15 m. ſails theſe ſeveral Courſes, *viz.* *W.* 23 m. *N.E.* 26 m. *N.* 8 m. *W.* 16 m. *N.* 50 m. *N.E.* 29 m. *S.E.* 29 m. *S.* 50 m. *W.* 16 m. *S.* 8 m. *S.E.* 26 m. *W.* 23 m. *N.* 75 m. *S.E.* 7 m. *S.W.* 6 m. *S.E.* 50 m. *N.E.* 14 m. *N.W.* 50 m. *S.W.* 6 m. *N.W.* 7 m.

N.E. 7 m. *S.E.* 6 m. *N.E.* 50 m. *N.W.* 14 m. *S.W.* 50 m. *S.E.* 6m. *S.W.* 7 m. *N.W.* 7 m. *NE.* 6 m. *N.W.* 50 m. *S.W.* 14 m. *S.E.* 50m. *N.E.* 6 m. *S.E.* 7m. *S.W.* 7 m. *N.W.* 6 m. *S.W.* 50 m. *S.E.* 14 m. *NE.* 50 m. *N.W.* 6 m. *N.E.* 7m. I demand the Lat. come into, *&c.*?

QUEST. VII. A Ship from the Lat. 45°. 30'. *S.* ſails as follows, *viz.* *N.E.* 89 m. *W.* 30 m. *S.E.* 59 m. *N.* 30 m. *S.W.* 59 m. *E.* 30 m. *N.W.* 59 m. *S.* 115 m. *N.E.* 59 m. *W.* 30 m. *S.E.* 59 m. *N* 30 m. *S.W.* 59 m. *E.* 30 m. and *N.W.* 59 m. I demand, *&c.*?

QUEST. VIII. A Ship in the Lat. of 50°. *N.* ſails as follows, *viz.* *E.* 20 m. *S.* 20 m. *W.* 10 m. *S.*$\frac{1}{4}$*W.* 115 m. *E.* 8m. *S.* 8m. *W.* 8m. *S.* 16m. *S.b.W.*$\frac{1}{2}$*W.* 23m. *N.b.W.*$\frac{1}{4}$*W.* 23m. *N.* 16 m. *W.* 8 m. *N.* 8 m. *E.* 8 m. *N.*$\frac{1}{2}$*W.* 115 m. *W.* 10 m. *N.* 20 m. *E.* 20 m. I demand, *&c.*?

QUEST. IX. A Ship meeting with contrary Winds, ſails from the Lat. of 40°. *N.* *viz.* *W.b.S* $\frac{1}{4}$*S.* 31 m. *E.b.S.* 8m. *W.b.S.* 10 m. *S.E.*$\frac{3}{4}$*E.* 3 m. *E.b.S.* 25 m. *E.* 35 m. *E.S.E.*$\frac{1}{2}$*S.* 30 m. *N.W.*$\frac{1}{2}$*N.* 20 m. *E.*$\frac{3}{4}$*N.* 55 m. *S.E.b.E.* 30 m. *N.W.b.N.* 25 m. *N.E.b.E.* 20 m. *W.S.W.*$\frac{1}{2}$*W.* 30 m. *W*,$\frac{1}{2}$*N.* 70 m. *S,E,b,S.* 20 m. *N,W,b,W.* 28 m *N,E,b,E.* 28 m. *S,W,b,S.* 20 m *W*,$\frac{1}{2}$*S.* 21 m. I demand the reſt?

QUEST. X. Sailing from the Lat of 51°, 32'. *N.* and meeting with contrary Winds, am conſtrain'd to ſail, *viz* *S,W.* 52 m. *S,S,W.* 14 m. *S,S,E.* 14 m. *S,E,b,E* 14m. *E.* 14 m. *N,N,E,*$\frac{1}{4}$*E.* 24 m. *S,S,E,*$\frac{1}{4}$*E* 24 m. *E.* 14 m. *N,E,b,E.* 14m *N,N,E.* 14m. *N,N,W.* 14m. *N,W* 52m. *S.* 78m *N,W* 7m. *S,b,E,*$\frac{3}{4}$*E* 19m. *N,b,E,*$\frac{3}{4}$*E.* 19 m. *S,W.* 7 m. I demand the reſt?

QUEST. XI. Admit from the Lat of 30° *N.* I ſail theſe Courſes, *viz* *N.* 21 m. *S,E* 85 m. *N,E.* 15 m. *N,W.* 70 m. *S,W.* 30 m. *S,E.* 30 m. *N,E.* 70 m. *N,W* 15m. *S,W.* 85 m. *N.* 21 m. *E.* 100 m. *W,N,W.* 34 m. *S,E.* 19 m. *S,W.* 19 m. *E,N,E.* 34 m. I demand the reſt?

QUEST. XII. Being bound to Cruiſe, from an Iſland in Lat 39° *N* I ſail as follows, *viz.* *N,N,E.* 32 m *N,N,W* 32 m. *S,S,W.* 32 m *S,S,E.* 32 m *E,N,E.* 32 m. *E,S,E.* 32 m *W,S,W.* 32 m. *W,N,W.* 32 m. *S,S,E.* 32m. *S,S,W.* 32m. *N,N,W.* 32m *N,N,E.* 32m. *W,S,W.* 32 m *W,N,W.* 32 m. *E,N,E.* 32 m. *E,S,E.* 32 m *S.* 60 m. *N,W.* 86 m *N.E* 86 m. *S,E* 86 m. *S,W.* 86 m I demand the Lat. in, Dep. Courſe and Diſt.?

QUEST. XIII. Admit a Ship from the Lat. 32°. 30'. *N* ſails theſe Courſes, *viz.* *S.* 10 m. *W.* 10 m. *S.* 30 m. *E* 30 m *S* 15 m. *W.* 30m. *S.* 30m. *W.* 15m. *N.* 30m. *W.* 30m. *N.* 15m. *E* 30m. *N* 30m *W.* 10 m.

W. 10 m. N. 10 m. W. 10 m. N. 10 m. W. 10 m. N. 10 m. W. 10 m. N. 10 m. I demand the reſt?

QUEST. XIV. Admit a Ship from the Lat. 45°. S. ſails, *viz.* S,E,b,E. 18 m. S. 20 m. E. 21 m. N. 10 m. E. 10 m. S. 10 m. E. 21 m. N. 10 m. E. 10 m. S. 10 m. E. 20 m. N. 40 m. N,W. 20 m. S,W. 20 m. W. 20 m. N. 20 m. W. 20 m. N. 20 m. W. 20 m. N. 20 m. W. 20 m. S. 20 m. W. 20 m. S. 20 m. W, 20 m. N,W. 20 m. S,W. 20 m. S. 40 m. E. 20 m. N. 10 m. E. 10 m. S. 10 m. E. 20 m. N. 10 m. E. 10 m. S. 10 m. E. 21 m. N. 20 m. N,E,b,E. 18 m. I demand, *&c.*

QUEST. XV. Admit a Ship departs from an Iſland in Lat. 41°. N. and ſails, *viz.* N,E. 60 m. S,S,W. 113 m. N,N,W, 113 m. S,E. 120 m; W,N,W. 113 m. E,N,E. 113 m. S,W. 120 m. N,N,E. 113 m. S,S,E. 113 m. N,W. 120 m. E,S,E. 113 m. W,S,W. 113 m. and N,E. 60 m. I demand, *&c.*

QUEST. XVI. Suppoſe a Ship ſails from the Lat. of 30°. N. theſe Courſes, *viz.* N. 35 m. E. 12 m. N, ½E. 60 m. S, ½E. 60 m. E. 12 m. N. 92 m. E. 6 m. S. 12 m. E. 6 m. N. 12 m. E. 6 m. S. 12 m. E. 6 m. S. S. 12 m. E. 6 m. N. 12 m. E. 6 m. S. 92 m. E. 12 m. N, ½E. 60 m. S, ½E. 60 m. E. 12 m. S. 35 m. W. 40 m. N. 19 m. N,W. 22 m. S,W. 22 m. S. 19 m. Idemand, *&c.*

QUEST. XVII. A Ship from Lat. 44°. 40'. N. ſails theſe ſeveral Courſes, *viz.* W. 105 m. N. 151 m. E. 15 m. S. 15 m. E. 15 m. N. 15 m. E. 15 m. S. 15 m. E. 15 m. N. 15 m. E. 15 m. S. 44 m. E. 18 m. N. 18 m. E. 18 m. S. 18 m. E. 18 m. N. 18 m. E. 18 m. S. 18 m. E. 18 m. N. 44 m. E. 15 m. S. 15 m. E. 15 m. N. 15 m. E. 15 m. S. 15 m. E. 15 m. N. 15 m. E. 15 m. S. 151 m. I demand the reſt?

QUEST. XVIII. Suppoſe a Ship from the Lat. 50° 30'. N. ſails, *viz.* S,W. 48 m. N. 34 m. E. 84 m. S. 34 m. N,W. 48 m. S. 34 m. E. 34 m. N,E. 29 m. N,W. 18 m. S,W. 18 m. S,E. 29 m. N,E. 48 m. S. 34 m. W. 34 m. S,b,W. 40 m. E,b,N. 40 m. N,E. 48 m. W. 34 m. S. 34 m. S,E. 29 m. N,E. 18 m. N,W. 18 m. S,W. 29 m. S. 34 m. E. 34 m. N,W. 48 m. W,b,N. 80 m. N,W. 48 m. E. 34 m. S. 34 m. S,W. 29 m. N,W. 18 m. N,E. 18 m. S,E. 29 m. S,W. 48 m. E. 34 m. N. 34 m. E,b,N. 40 m. I demand the reſt?

QUEST. XIX. Admit a Ship ſails from a Port in the Lat. of 46°. 30'. N. meeting with contrary Winds, ſails as follows, *viz.* N,W,b,N. 40 m. E. 15 m. N,E. 30 m. S,E. 10 m. S,W. 10 m. N,W. 30 m. N,E. 10 m.

10 m. S,E. 10 m. S,W. 30 m. N,W. 10 m. N,E. 10 m. S,E. 30 m. E. 15 m. S,W,b,S. 40 m. N,E,b,E. 40 m. S. 15 m. S,E. 30 m. S,W. 10 m. N,W. 10 m. N,E. 30 m. S,E. 10 m. S,W. 10 m. N,W. 30 m. N,E. 10 m. S,E. 10 m. S,W. 30 m. S. 15 m. N,W,b,W. 40 m. S,E,b,S. 40 m. W. 15 m. S,W. 30 m. N,W. 10 m. N,E. 10 m. S,E. 30 m. S,W. 10 m. N,W. 10 m. N,E. 30 m. S,E. 10 m. S,W. 10 m. N,W. 30 m. W. 15 m. N,E,b,N. 40 m. S,W,b,W. 40 m. N. 15 m. N,W. 30 m. N,E. 10 m. S,E. 10 m. S,W. 30 m. N,W. 10 m. N,E. 10 m. S,E. 30 m. S,W. 10 m. N,W. 10 m. N,E. 30 m. N. 15 m. S,E,b,E. 40 m. I demand the reſt?

QUEST. XX. A Ship ſails from an Iſland in the Lat. 49°. 10. N. theſe ſeveral Courſes, *viz.* N 149 m. E 10 m. S. 33 m. N,E,b,E. 5°. E. 23 m. S,E,b,E. 5°. E. 23 m. S. 5 m. S,E,b,E. 5°. E. 14 m. E. 13 m. N. 36 m. E. 10 m. S. 24 m. N,E,b,E. 5°. E. 26 m. S,E,b,E 5°. E 26 m. N. 24 m. E. 12 m. S. 37 m. E. 16 m. N,E,b,E. 5°. E. 13 m. N. 6 m. N,E,b,E. 5°. E. 22 m. S,E,b,E. 5°. E. 22 m. N. 25 m. E. 10 m. S. 149 m. W. 28 m. N. 112 m. W. 28 m. S. 112 m. N,W,b,W. 5°. W. 47 m. N. 40 m. E. 4 m. N. 4 m. W. 35 m. S. 4 m. E. 4 m. S. 40 m. S,W,b,W. 5°. W. 48 m. N. 112 m. W. 29 m. S. 112 m. W. 30 m. I demand the reſt?

QUEST. XXI. Admit two Ships ſail from a certain Iſland, in Lat. 30°. N. to Cruiſe for 13 Days; the firſt ſails W. 40 m. N,E. 22 m. N. 30 m. W,N,W. 15 m. E,N,E. 15 m. N. 30 m. N,W. 22 m. E. 40 m. S,W. 22 m. S. 30 m. E,S,E. 15 m. W,S,W. 15 m. S. 30 m. The other Ship ſteers away, *viz.* E. 40 m. N,E. 22 m. N. 60 m. N,W. 22 m. E. 40 m. S,W. 22 m. S. 30 m. N,E. 57 m. W,N,W. 17 m. E. 38 m. W,S,W. 20 m. S,W. 68 m. N,E. 8 m. S,E. 68 m. E,S,E. 17 m. W. 40 m. E,N,E. 17 m. N,W. 63 m. I demand each Ship's *x.* Lat. Dep. Direct Courſe, and Diſt. from the Iſland; alſo the Latitude they are both come into?

In this laſt Queſtion, is projected the Two Firſt Letters of the AUTHOR's *Name, in* Roman *Capitals.*

To Meaſure BALES *or* CASES, *and to find their Tunnage.*

IT is of frequent Uſe in the River of *Thames*, for the Commanders or Mates of Ships, (taking in Bale Goods,) to caſt up their Tunnage. Now theſe Bales, *&c.* are generally

Square

Square Priſms, or *Long Square Solids*; or to be eſteemed ſo, if Round as a *Cylinder*, (or Rolling-Stone of a Garden;) becauſe they occupy the ſame Space in the Hold as Square Ones: The General Rule for their Content in Feet, is,

To Multiply their Breadth, Depth, and Length together; and then, to reduce theſe Feet into Tuns, we muſt know how many Solid Feet is equal to a Tun: Till this is agreed on, no exact Anſwer can be found. And firſt, 'tis found by Experience, 66 Foot is the Content of a Caſe that incloſeth Two *Engliſh* Buts; which is generally eſteem'd as equal to One Tun: But then, this Rule excludes the Cantlings or Vacuity of the ſaid Buts within the Caſe, which is allow'd to be ſomething more than $\frac{1}{3}$ Part, or 26 Feet. If therefore we allow the Cantlings or Vacancy to be 26 Feet, and deduct it from 66 Feet, reſts 40 Feet to be accounted as One Tun. But Others again plead, that every Cubick Foot of Water, doth weigh 55 Pound Avoirdupoize: But Dr. *Wybard*, (who was very diligent this Way) finds every Cubick Foot of Water to weigh 62, lb. 588. Now in a Tun, or Twenty Hundred Weight, there is 2240 Pounds: And if you divide 2240 by 62,588, the Quote is 35,79 Feet; by this Experiment.

But $\frac{2240}{55} = 40,7$, agreeing nearly with the firſt Way, and which we ſhall make uſe of; therefore the Rule is,

As 40 is to the *Area* of the End, ſo is the Length to the Content in Tuns.

Example I.

A Box, Bale or Caſe, whoſe { Breadth 6, Depth 4, Length 10 } Feet,

How many Feet and Tuns doth it contain?

Facit. 240 Feet, or 6 Tuns.

D. Ar. End.

Br. 6 X 4 = 24 Feet. X 10 Feet = 240 Feet. Content.

And 4 (o) 24 (o (6 Tuns.

Ar. Baſe. Leng.

Or thus: As 40 -- 24 :: 10 -- 6 Tuns. *Facit.*

Note. If the Dimenſions be taken in Feet and Inches, your beſt way is to reduce the odd Inches of each Foot into Decimals; which may be eaſily done by the following Table of the Decimals of Inches.

The TABLE.

Inch.	*Decims.*
1	,083
2	,166
3	,25
4	,333
5	,416
6	,5
7	,583
8	,666
9	,75
10	,833
11	,916

Example II.

A Bale, *&c.* whose

	F. Inch.		*Feet.*	
Breadth	4 : 3		4,25	
Depth	2 : 8	or *per* Table	2,66	What
Length	5 : 9		5,75	

is the Content in Tuns? *Facit.* 1,65. Or, 1 Tun, 13 C.

4,25 B.
2,66 D.

2550
2550
850

11,3050 Area of the End.
5,75 Length.

56525
79135o
565250

66,003750 Content in Feet.

Divide by 40)66,00[3750(1,65 Tun.
Multip. by 20 the Hundreds in a Tun,
26
C. 13,00 *Facit.* 1 Tun, 13 C.
20

But, if the Learner is unacquainted with Decimal Arithmetick, he may reduce each Foot and Inches into Inches; and Multiplying the Dimensions into one another, the Content thus found in Inches, Divided by 1728, the Solid Inches in a Foot, gives the Content in Feet; and this, Divided again by 40, Quotes the Tuns.

Example III.

A Bale or Case, whose

	F. In.
Breadth is	4,6
Depth	3,4
Length	9,2

What's the Content in Tuns? *Facit.* 3 Tuns, $8\frac{1}{2}$ C.

54 In B.
40 D.
2160
110 L.
237600 Content in Inches.

1728) 237600 (137 Feet the Content.

Tun. C.
4|0) 13|7 (3 : 8½. *Facit.*

Hundreds in a Tun 1 7
2 0
C.
4|0) 34|0 (8
2
Quarters in a C. 4
qrs.
4|0) 8|0 (2

In Case you take on Board several Bales or Cases at one Time, 'tis best to take their Marks, Numbers and Dimensions, and enter them in a Table in your Pocket-Book, as here-under; and so find their Tunnage at your own convenient Time, if you are employ'd in Stowing them in the Hold, or otherwise.

Month. Day.	Mark	N°.	Breadth. *Feet, Inc.*	Depth. *F. In.*	Length. *F. In.*	Content in Feet.	Ct. in Tuns. *T. C. qrs.*
1723. Feb. 3.	ST	1	6 : 0	4 : 0	10 : 0	240.	6 : 0 : 0
4.	AR	2	4 : 3	2 : 8	5 : 9	66,00375	1 : 13 : 0
5.	ZC	3	4 : 6	3 : 4	9 : 2	137.	3 : 08 : 2

To find the Burthen of a Ship.

FInd the Burthen of any Ship; that is, to Gauge her Hold, or find her Tunnage.

There are several Ways for Performance hereof, by *Ship-Builders*; but I shall only Instance in one Way, as used by the

Sworn Measurers: The Rule is thus, *viz.*, Take $\frac{3}{5}$ Parts of the Ship's Breadth, and Substract it from the Length, (taken from the Stern-Post, to the Foot of the Perpendicular dropt from the upper Part of the Stem;) the Remainder multiply'd by the Whole Breadth, and that Product again by the $\frac{1}{2}$ Breadth; the last Product, Divided by 100 for *Kings*, or 94 for *Merchants*, (gives the) Tunnage.

Example.

Suppose a Ship, 74 Feet in Length (from the Stern-Post to the Foot of the Perpendicular, from the upper Part of Stem;) and her Extream Breadth, from Out-side to Out-side, 26 Feet: What is this Ship's Tunnage?

2) 26 (13. Half Breadth. And 5) 26 (5,2
25
1,0
3
15,6 the $\frac{3}{5}$ Parts of (the Breadth.

	F.		
Then from the Length	74,0		
Take the $\frac{3}{5}$ of Breadth	15,6		
	Breadth.		$\frac{1}{2}$ *Breadth.*
Rests	58,4	X26=1518,4; this	X13=19739,[2

Tun.

1[00) 197[39 (197,$\frac{39}{100}$ King's Tunnage.) and 94) 19739 (209$\frac{93}{94}$, or very near 210 Tun, Merchant's Tunnage. *Facit.*

To Gauge or Measure a Butt, Pipe, Puncheon, Hogshead, Barrel, or any (Spheriodical) small Cask.

Rule.

YOU must first reduce it to a *Cylinder*, that is, find a mean Diameter between the Head and the Bong thus; find the Difference between the Bung and Head Diameter; this Difference multiply'd by $\frac{7}{10}$, and added to the Head Diameter, gives the Mean Diameter; this Sum Squar'd and Divided by 294, Quotes the Area of the Cask; which multiply'd by the Length, gives the Content in Wine Gallons; or if Divided by 359, the Quantity of Ale Gallons requir'd.

Example.

Suppose a Cask whose Bung Diameter is 31 Inches; Head Diameter 24 Inches, and its Length 47 Inches, what is the Content in Wine or Ale Gallons?

B.D. 31. — H.D. 24 = 7 X ,7 = 4,9.
And H.D. 24 + 4,9 = 28,9 Mean Diam.
Then 28,9 X 28,9 = 835,21.

And

And { 294) 835,21 (2,84 } Area in { Wine Gallons.
{ 359) 835,21 (2,32 } { Ale Gallons.

Leng. *Gall.*

2,84 X 47 = 133,48 } Content in { Wine Gallons.
2,32 X 47 = 109,04 } { Ale Gallons.

A Table for Gauging Wine-Casks, when full.

The Diameter in Inches. D	Head G. Pts.	Bung G. Pts.	D.	Head G. Pts.	Bung G. Pts.	D.	Head G. Pts.	Bung G. Pts.	D.	Head G. Pts.	Bung G. Pts.
1	0.001	0.002	16	0.290	0.580	31	1.085	2.178	46	2.398	4.796
2	0.004	0.009	17	0.328	0.517	32	1.10[illegible]	2.321	47	2.503	5.007
3	0.010	0.020	18	0.367	0.734	33	1.235	2.468	48	2.611	5.222
4	0.018	0.036	19	0.409	0.818	34	1.31[illegible]	2.62[illegible]	49	2.721	5.442
5	0.028	0.056	20	0.453	0.906	35	1.388	2.776	50	2.833	5.666
6	0.041	0.081	21	0.500	1.000	36	1.469	2.938	51	2.948	5.896
7	0.056	0.111	22	0.548	1.097	37	1.551	3.102	52	3.064	6.129
8	0.072	0.145	23	0.599	1.199	38	1.636	3.272	53	3.183	6.367
9	0.092	0.184	24	0.653	1.306	39	1.724	3.448	54	3.305	6.610
10	0.113	0.226	25	0.708	1.416	40	1.813	3.626	55	3.428	6.856
11	0.137	0.274	26	0.766	1.532	41	1.904	3.809	56	3.554	7.108
12	0.163	0.326	27	0.826	1.652	42	2.000	4.000	57	3.682	7.364
13	0.192	0.383	28	0.888	1.777	43	2.096	4.192	58	3.812	7.625
14	0.222	0.444	29	0.953	1.906	44	2.194	4.388	59	3.945	7.890
15	0.255	0.510	30	1.020	2.040	45	2.295	4.591	60	4.080	8.160

2. By this Table.

The Table shews for 24 Inches Head Diameter . . 0.653
For the Bung Diameter 31 Inches — . . 2.178

Their Sum is the Mean Diameter — 2.831
Which Multiply by the Length 1 — 47

19817
11324

Product is the Content Wine Gallons. 133.057

To turn Wine Gallons into Ale Gallons, and *contra*, this is the Proportion.

As $\left\{\begin{matrix}282\\94\\5\end{matrix}\right\}$ is to $\left\{\begin{matrix}231\\77\\4\end{matrix}\right\}$ so is the Content in Wine Gallons, to the Content in Ale-Gallons: For

Note, The Wine Gallon contains 231, and the Ale Gallon 282 Solid Inches; or, 231 Gallons of Wine makes 282 Gallons of Ale.

The Use of this Table.

A TABLE for Gauging Wine-Casks which are not full.

G.	Parts	G.	Parts	G.	Parts	G.	Parts
0	000		2980	31	4943		6877
½	295	16	3056		5000	47	6944
1	470		3123	32	5057		7012
	602	17	3189		5115	48	7082
2	720		3255	33	5174		7153
	830	18	3321		5234	49	7225
3	935		3387	34	5294		7297
	1038	19	3452		5354	50	7370
4	1138		3517	35	5415		7444
	1235	20	3582		5476	51	7519
5	1339		3647	36	5535		7595
	1420	21	3712		5600	52	7672
6	1502		3777	37	5662		7758
	1596	22	3848		5724	53	7829
7	1681		3906	38	5787		7909
	1764	23	3960		5850	54	7990
8	1846		4024	39	5913		8072
	1918	24	4087		5976	55	8154
9	2010		4150	40	6040		8236
	2091	25	4213		6094	56	8319
10	2171		4276	41	6158		8404
	2242	26	4338		6223	57	8491
11	2328		4400	42	6288		8580
	2405	27	4462		6353	58	8661
12	2481		4542	43	6418		8765
	2556	28	4585		6483	59	8862
13	2630		4646	44	6548		8962
	2703	29	4706		6613	60	9065
14	2775		4766	45	6670		9170
	2847	30	4826		6745	61	9280
15	2918		4885	46	6811	63	10000

The Table is made to Gallons and Half Gallons, and by Proportion may go nearer. *Rule:* Find the Content of the whole Cask, and find how deep the Liquor is within the Cask; then say,

As the Diameter at the Bung in Inches, to the Depth of Liquor; so the Rad. of the Table 10000, to the Proportional Part. Find in the Table the Gallons and Parts, that answer that Part Proportional; then say again,

As 63 Gallons, the Gall. of the Rad. is to the Proportional Gall, found; so is the Content of the whole Cask, to the Content of the Liquor in the Cask.

Example.

Let the Cask be as before, 31 Inches at Bung, and the Liquor 24 Inches Deep.

	In.
As the Diam. at Bung	31
To the Depth of Liquor	24
So is the Radius of the Table	10000
To the Part Proportional	7741

Find this Number 7741, (or nearest to it in the Table, and it answers very near to 52½ Gall. Then say again,

As

		G	Pts.
As the Gallons of the Radius	——	63	00
To the Proportional Parts found	——	52	5
So is the Content of the whole Cask,		133	0
To the Content of the Liquor being 24 Inches Deep		110,	$\frac{11}{16}$

That is, somewhat above 110 Gallons, and Three Quarters.

The Ullages of an Engliſh *Butt that holds* 108 *Gallons, Ale Meaſure; whoſe Head Diameter is* 31 *Inches, and Bung Diameter* 31 *Inches, and Length* 46 *Inches.*

THE Uſe of this Table is plain and eaſie; for here is the Quantity of Gallons contain'd in the Wet Inches of the Bong Diameter, under W; and the Wants, or (Dry) Gallons out, under D, againſt the Wet Portion.

B.	W.	D.	B.	W.	D.
0	G. P.	G. Pts.	0	G. Pts.	G. P.
1	0.54	107.46	17	61. 5	46.5
2	2.00	106. 0	18	66. 3	41.7
3	4.03	103. 7	19	71. 3	36.7
4	6.00	102. 0	20	76. 0	32.0
5	8. 3	99. 7	21	80. 0	28.0
6	12.0	96. 0	22	84. 5	23.5
7	16.4	91. 6	23	88. 6	19.4
8	19.4	88. 6	24	91. 6	16.4
9	23.5	84. 5	25	96. 0	12.0
10	28.0	80. 0	26	99. 7	8. 3
11	32.0	76. 0	27	102. 0	6. 0
12	36.7	71. 3	28	103. 7	4. 3
13	41.7	66. 3	29	106. 0	2. 0
14	46.5	61. 5	30	107.46	0.54
15	51.5	56. 5	31	108.00	0. 0
16	56.5	51. 5			

The Decimals anſwering to Quarts and Pints, are

,25 = 1 Quart. ,5 = 2 Quarts.
,75 = 3 Quarts. ,125 = 1 Pint.

Theſe Gallons of Ale may be turn'd into Gallons by the Reverſe of the Rule foregoing.

Of GUNNERY.

TO find how much Powder is ſufficient both for Action and Proof of any Piece of Ordnance, take this RULE. Multiply the Weight of the Ball, by the Calibers in the Circumference of the Breech; and for Proof, Multiply this Product by 8; for Service, Multiply the ſame by 6: This laſt

laſt Product, Divided by 96, gives the Number of Pounds of Powder.

Example.

Suppoſe a Cannon Ball of Iron weighs 24 *l.* fit for a Gun whoſe Breech contains 9 Calibers, or Diameters of the Bore in Circumference; I demand the Quantity of Powder fit for Proof and Action?

Ball	24 *l.*		24 *l.*
Calib.	9		9
	216		216
	8		6
96)	1728 (18 *l.* Proof.	96)	1296 (13 $\frac{48}{96}$ or 13 *l.* for Service or Action.

This Rule is Short and Eaſie: Uſe it, or thoſe deliver'd by Others; and let your own Experience prove or diſprove it.

To make any DIAL *to any Plane, whether Direct, Declining, Reclining or Inclining; Crooked, Bended, or any ways Uneven, without any notice taken of ſuch Declination, Reclination,* &c.

DO thus, by the help of a Large and Good Horizontal Dial, (to be had at the Inſtrument-Maker's,) which muſt have a ſmall Hole in the Center, to ſuffer a Silk Thread or Hair to go through. You may work thus: Under the Plane, where you intend to make a Dial, draw a Level Horizontal Line, by a Carpenter's or other Level; to this Line ſet a Scaffold or Frame of any Board or Boards, deep, according to the Bigneſs you intend the Dial to be; this Scaffold muſt be Level likewiſe.

This being fitted, and by any other True Dial or your Minute-Watch, rectify'd; find the true Time of the Day, and placing your Horizontal Dial upon the Level-Plane, keeping it to the true Time of the Day by moving it to and fro; you may, by the Thread from the Center, carried by the Edge of the Gnomon or Stile, find out the Center of the New Dial, if it will have a Center; which Mark, and by ſmall Tacks faſten your Horizontal Dial in that Place, that it may not move the Thread or Hair carry'd by the Edge of the Gnomon;

mon, if continued in either Pole, and is the Gnomon to the New Dial; the Perpendicular Line under it, taken by a Square, is the Subſtyler, and the Style may be faſtned to the Plane by help of that Thread.

Now to draw the Hour-Lines, do this, Lay the Thread fix'd to the Center of the Horizontal Dial, over the Hour-Lines and Quarters, and mark out in the Horizontal Line, on the Plane, where they Interſect: Lines drawn from the Center of the New Dial to theſe Points, are the Hour-Lines: But ſome Hour-Lines may run off the Plane, or by reaſon of their Crookedneſs, or ſome Pillars may hinder; to help this, draw as large a Square or Oblong upon the Horizontal Plane as you may, and transfer (by help of the Center-Thread) all the Hours from the Horizontal Dial, into the Lines of the Outſide of the ſaid Square or Oblong. Now if you bring a Thread from the Center of the New Dial, and reſt it upon the Hour-Points mark'd in the ſaid Square, the Center-Thread of the Horizontal Dial, carry'd only to touch the other Thread, will deſcribe the Hour-Line deſir'd, whether upon an Even or Uneven Plane, that have Centers for the New Dial: But if the Line carry'd by the Edge of the Gnomon of the Horizontal Dial, will not meet with the Plane, as in all Eaſt and Weſt Planes much declining, then muſt you fix up a Board or other Matter, to receive the Center by the Side of the Plane; and then fixing a Thread there, by that and the other Thread, you may ſtrike all the Hour-Lines, as was before ſhewed, in Crooked Planes; and the Thread from the Centers, being the New Gnomon, muſt be fixed to the Wall by Two Stays.

This may be practis'd with as much Curiſioty as any other, and will be Sure and Exact.

Of the moſt Rational Ways that hath hitherto been propos'd to find the LONGITUDE *at Sea, by Obſervation.*

WHich are theſe Five, *viz.* I. By an Eclipſe of the Moon.

II. By the Moon's Place in the Zodiack given.

III. By the Eclipſes of *Jupiter's Satellites*, or *Circumjovials*.

IV. By a Clock, Watch, or Hour-Glaſs.

V. By the Diſtance betwixt the Moon and ſome known fixed Star, ſituate near the Ecliptick.

IF

IF the Longitude could be as certainly found out at Sea, as the Latitude, it would render Navigation perfect. Yet, hitherto, tho' many of the ableſt Mathematicians in *England* (and elſewhere) have attempted it, but never accompliſh'd it. *Theaker*, in his *Planiſphere*, tells us, he can by that Inſtrument, as certainly find out Longitude, as to find the Riſing, Setting, and Southing of the Stars: But if he could, he does very ill expreſs it; and therefore, we may conclude, that *Aliquid latet quod non patet*; and perhaps he might keep a Reſerve to himſelf on purpoſe. Others (ſince the late Act of Parliament has been pleas'd to offer ſuch a Liberal and Plentiful Gratuity to him that ſhall firſt diſcover it) have exerted their utmoſt Induſtry for attaining this End: Some of whom have been ſo far from compleating their Deſign, that they have rather render'd themſelves and their Works ridiculous; by publiſhing ſuch Abſurd, Improper, and Improbable Methods. But to wave all theſe, we ſhall only inſert ſuch Methods as may ſeem moſt probable.

The Proceſs for finding the Longitude of any Place, depends upon the Inequality of the Motion of the Celeſtial Bodies; for if both the fixed Stars and Planets, be mov'd with an Equal Degree of Velocity from Eaſt to Weſt; every of theſe in the ſame Number of Hours ſhall paſs through all the Meridians of the whole Earth: But by reaſon of the Inequality of the Motion of the Celeſtial Bodies, if any fixed Star come to any Meridian at Twelve at Midnight, it ſhall come to that Meridian that is 90°. Diſtant to the Weſtward, at 11 h. 59 m. and conſequently the Error of one Minute of Time in Motion, produceth an Error in Longitude of about 90 Degrees.

Alſo the Moon (whoſe Motion is ſwifteſt of all) comes to any Meridian at 12 a Clock: She ſhall come to a Meridian which lies 7°. 12'. Weſtward, about 12 h. 1 m. and therefore, from the Error of one Minute of an Hour in the Moon's Motion from the Sun, ariſeth an Error of 7°. 12 m. in the Longitude of the Place propounded: And in the Motion of the Moon from any fixed Star, riſeth an Error of 6°. 48'.; and in the reſt of the Planets, after the ſame manner, the Error increaſeth; both from the Planet's Place, taken by Obſervation, and from the Tables calculated according to the Proportion between the Motion of the Planet obſerv'd, and the Motion of the *Primum Mobile*.

From which, we may infer, that ſeeing the Difference of Longitude cannot be obtain'd by help of Celeſtial Obſervations, unleſs the exact Time be known between both Places, whoſe Diffe-

Difference of Longitude is ſought; it is obvious, that if the Errors at both Places be not of the ſame Denomination, and leſſer than 1 Minute of Time, the Error of Longitude cannot be leſs than 13 Degrees.

Hence, 'tis manifeſt how difficult (if not impoſſible) it is, to find the Ship's Longitude at Sea, by Obſervation of the Celeſtial Bodies. However, the Deſign here is to ſhew the various METHODS propos'd, and that there is not ſuch a Myſtery in this Notion of Longitude, as our vulgar Seamen commonly imagine. See *Varenius* and *Carpenter's Geography*, P. 416,417,418,420, *&c.* and *Newton's Idea. Nautic.* P.79,80, *&c.* collected from the ſame.

METHOD I.

To find the Longitude of any Place by an Eclipſe of the Moon.

AT the Moment of Time, when through a good Teleſcope, you obſerve the Beginning, Middle, or End of an Eclipſe, you muſt take the Altitude of a Fixed Star, whether it be upon the Meridian or in any Azimuth, it matters not: But if the Star be on the Meridian, you may (if you knew it not before) find the Lat. of the Place. Which Aſtral Altitude being taken, find the Hour of the Night with all poſſible Exactneſs; which is moſt eaſily done by this following Rule: *viz.* If the Star be upon the Meridian, to the Complement of the Sun's Right-Aſcenſion in Hours and Minutes, add the Star's Right-Aſcenſion in Hours and Minutes: The Sum is the Time requir'd. Compare this Time of the Night thus found, with the Time of the Beginning, Middle, or End of the Eclipſe, found by the *Almanack* or *Ephemeris* calculated for that Eclipſe; and the Difference in Time, between the Place for whoſe Meridian the *Ephemeris* was calculated, and the Place where this Obſervation was made; aad then the Long. of the Place where this Obſervation was made, may be found by converting the Hours and Minutes, in the Difference in Time between the Two Places, into Degrees and Minutes of the *Equator*.

This Method would be very accurate and uſeful, if we could ſee an Eclipſe every Night: But as Eclipſes ſeldom happen, and when they do, are not viſible in all Places; therefore, it is not ſo uſeful at Sea, being rather accommodated to the Shore: And thereby, the Longitudes of moſt Places were diſcover'd.

METHOD II.

To find the Longitude of any Place, having the Moon's Place in the Zodiack given.

FIND the true Time in which the Moon comes to the Meridian; and thereby find the Longitude. Thus;

The Lat. being known in the Place of Obſervation; find the Altitude of any known Star, and thereby the Time of the Night with all imaginable Accuracy. (But note, that the Altitude of the Star, muſt be taken preciſely when the Moon is upon the Meridian.) Next find what Degree or Minute of the Zodiack or Ecliptick is in the *Medium Cæli*, at that ſame Time exactly: And thus for the Time found, we have the Moon's true Place in the Zodiack.

Then from the Tables calculated for the Meridian of that *Almanack* or *Ephemeris*, find the Hour in which the Moon ſhall be in that Point of the Zodiack; and we ſhall have the Horary Difference in Time, between the Two Places; *viz.* Of the Place where the Obſervation was made, whoſe Long. is unknown; and alſo, of that Place to whoſe Meridian the *Ephemeris* was calculated: And then proceed as in the former Method.

METHOD III.

To find the Longitude of any Place, by the Eclipſes of Jupiter's Satellites.

ABOUT the Glorious Planet *Jupiter*, there are Four *Satellites*, Moons or Companions, (Inviſible to moſt naked Eyes, though very eaſily perceiv'd through a Teleſcope;) which continually move round about *Jupiter*, reſpecting him as their Common Center: Their proper Motion, by which they are carried about *Jupiter*, (for their Diurnal Motion, and their Motion in the Ecliptick, is common to all the fixed Stars, to *Jupiter* and the reſt of the Planets,) is ſwift: That which is neareſt to *Jupiter*, finiſheth his Circuit, in

1 Day, 18 Hours, 28 Minutes, 36 Seconds.

		Days : *Hou.* : ′ : ″
The Second in	——	3 : 13 : 17 : 54
The Third in	——	7 : 03 : 59 : 36
The Fourth in	——	16 : 18 : 05 : 03

A TABLE of the Eclipſes of *Jupiter's Satelites*, Viſible under the Meridian of the Obſervatory. *Anno* 1693.

January.

D.	H. M.	*Satel.*
2	8. 7	4. I.
2	10.51	4. E.
3	11.23	2. E.
4	9. 40	3. I.
4	12.49	3. E.
5	14.02	1. E.
7	8. 32	1. E.
10	13.58	2. E.
11	13.39	3. I.
14	10.24	1. E.
16	4. 53	1. E.
19	5. 02	4. E.
21	5. 21	2. E.
21	12.18	1. I.
23	6. 47	1. E.
28	8. 28	2. E.
28	14.14	1. E.
30	8. 42	1. E.

February.

D	H. M.	*Satel.*
2	3. 50	3. I.
4	11. 5	2. E.
6	10.38	1. E.
8	5. 7	1. E.
9	5. 48	3. I.
9	8. 53	3. E.
11	13.33	2. E.
13	12.35	1. E.
15	7. 4	1. E.
16	9. 43	3. I.
16	12.55	3. E.
22	5. 41	2. E.
22	0. 01	1. E.

March.

D	H. M.	*Satel.*
1	8. 21	2. E.
1	10.50	1. E.
8	11. 0	2. E.
10	7. 36	1. E.
10	8. 53	4. E.
10	11.54	4. E.
17	9. 24	1. E.
24	9. 13	3. E.
24	12.22	1. E.
31	10.00	3. I.

April.

D	H. M	*Satel.*
2	7. 48	1. E.
2	8. 17	2. E.
9	9. 45	1. E.
9	10.56	2. E.
25	8. 8	1. E.

May.

D.	H. M.	*Satel.*
2	10. 3	1. E.
4	8. 8	2. E.
6	9. 27	3. E.
10	9. 24	4. I.

♂ ☉ ♃

July.

D.	H. M.	*Satel.*
3	15.15	2. I.
5	15.25	4. I.
15	15.38	1. I.
31	13.57	1. I.

Auguſt.

D	H. M.	*Satel.*
4	14.55	2. I.
7	15.51	1. I.
14	13.53	3. I.
14	17.07	1. I.
23	14.11	1. I.
30	16. 7	1. I.

September.

D.	H. M.	*Satel.*
5	14.41	2. I.
8	12.32	1. I.
10	15.41	4. I.
15	14.27	1. I.
19	13.26	3. E.
22	16.23	1. I.
26	13.57	4. I.
26	17.27	4. E.
27	14. 3	4. E.
29	18.18	1. E.
30	11.50	2. E.

October.

D.	H. M	*Satel.*
1	12.47	1. I.
3	17.57	3. I.
7	14.26	2. I.
8	14.41	1. I.
14	16. 2	2. I.
15	16.35	1. I.
22	18.29	1. I.
24	12.58	1. I.
25	9. 24	3. E.
31	11.50	1. I.

November.

D.	H. M.	*Satel.*
1	9. 52	3. I.
1	11.28	2. I.
1	13.24	3. E.
2	9. 19	1. E.
7	16.42	1. I.
8	13.49	3. I.
8	4. 1	2. I.
8	17.20	1. E.
9	11 [illegible]	1. I.
14	18.34	1. I.
15	16.34	2. I.
15	17.45	3. I.
16	13. 3	1. I.
16	15.46	4. I.
16	20.15	4. E.
18	7. 30	3. I.
22	19. 6	2. I.
23	14.53	1. I.
25	9. 20	1. I.
26	8. 22	2. I.
30	16.41	1. I.

December.

D.	H. M.	*Satel.*
2	11.10	1. I.
3	9. 39	4. I.
3	11. 2	2. I.
3	14.12	4. E.
7	18.33	1. I.
9	13.01	1. I.
9	13.26	2. I.
11	7. 28	1. I.
14	9. 26	3. I.
16	14.50	1. I.
17	15.57	2. I.
18	9. 18	1. I.
20	8. 8	4. E.
21	5. 13	2. I.
21	13.22	3. I.
23	16.42	1. I.
24	18 [illegible]	2. I.
25	11.10	1. I.
27	5. 39	1. I.
28	17.18	3. I.
30	18 33	1. E.

8 ☉ ♃

A CATALOGUE of the Eclipses of *Jupiter's Satelites*, Visible under the Meridian of the Observatory, or near it. *Anno* 1694.

January.

D.	H.	M.	*Satel.*	
1	15.	20	1.	E.
3	9.	48	1.	E.
4	13.	03	2.	E.
5	4.	16	1.	E.
8	17.	12	1.	E.
10	11.	40	1.	E.
11	15.	51	2.	E.
12	6.	8	1.	E.
15	5.	4	2.	E.
17	13.	33	1.	E.
18	18.	21	2.	E.
19	3.	2	1.	E.
19	8.	44	3.	E.
22	15.	18	4,	I.
22	13.	39	2.	E.
24	15.	07	1.	E.
26	8.	56	1.	E.
26	12.	43	3.	E.
28	4.	24	1.	E.
29	10.	15	2.	E.
31	17.	22	1.	E.

February.

D.	H.	M.	*Satel.*	
2	11.	40	1.	E.
4	6.	19	1	E.
5	12.	51	2.	E.
8	9.	25	4.	I.
8	14.	05	4.	I.
9	13.	46	1.	E.
9	17.	08	3.	I.
11	8.	15	1.	E.
12	15.	28	2.	E.
16	14.	42	1.	E.
18	10.	12	1.	E.
19	18.	06	2.	E.
23	7.	25	2.	E.
24	4.	28	3.	E.
25	8.	21	4.	E.
25	12.	9	1.	E.
27	6.	37	1.	E.

March.

D	H.	M.	*Satel.*	
2	10.	14	2.	E.
3	8.	50	3.	E.
4	14.	06	1.	E.
6	8.	35	1.	E.
9	12.	43	2.	E.
1	9.	16	3.	I.
10	12.	52	3.	E.
11	16.	03	1.	E.
13	10.	32	1.	E.
17	13.	18	3.	I.
17	16.	55	3.	E.
20	12.	30	1.	E.
22	7.	0	1.	E.
27	7.	20	2.	E.
29	8.	57	1.	E.
30	15.	58	4.	I.

April.

D.	H.	M	*Satel.*	
3	9.	56	2.	E.
5	10.	56	1.	E.
10	12.	27	2.	E.
12	12.	52	1.	E.
14	7.	21	1.	E.
15	9.	04	3.	E.
16	10.	06	4.	I.
21	9.	17	1.	E.
22	9.	28	3.	I.
22	13.	05	3.	E.
28	11.	13	1.	E.
29	13.	20	3.	I.

May.

D.	H.	M	*Satel.*	
5	9.	47	2.	E.
14	9.	31	1.	E.
28	9.	43	3.	E.

June.

D	H.	M.	*Satel.*	
3	9.	3	4.	E.
6	9.	41	1.	E.

July.

☌ ☉ ♃.

Auguſt.

D.	H.	M.	*Satel.*	
3	17.	3	1.	I.
5	16.	32	2.	I.
19	15.	23	1.	I.
28	15.	16	4.	E.

September.

D.	H.	M.	*Satel.*	
11	15.	39	1.	I.
12	17.	19	3.	I.
18	17.	25	1.	I.
23	13.	59	1.	I.

October.

D.	H.	M.	*Satel.*	
1	13.	26	2.	I.
4	15.	54	1.	I.
8	16.	02	2.	I.
11	12.	5	3.	E.
11	17.	49	1.	I.
15	18.	38	2.	I.
18	13.	12	3.	I.
18	16.	49	3.	E.
25	17.	10	1.	I.
27	16.	4	1.	I.

November.

D	H.	M.	*Satel.*	
3	17.	57	1.	I.
4	15.	16	4.	E.
5	12.	25	1.	I.
12	14.	16	1.	I.
16	18.	8	2.	I.
19	16.	7	1.	I.
21	10.	34	1.	I.
23	13.	30	3.	E.
26	17.	47	1.	E.
27	9.	54	2.	I.
28	12.	24	1.	I.

December.

D.	H.	M.	*Satel.*	
4	12.	26	2.	I.
5	14.	14	1.	I.
7	16.	42	3.	I.
11	14.	56	2.	I.
1	16.	4	1.	I.
14	10.	32	1.	I.
18	7.	28	2.	I.
19	17.	54	1.	I.
21	12.	21	1.	I.
23	16.	6	4.	I.
26	19.	43	1.	I.
28	14.	11	1.	I.
29	9.	13	2.	I.

The Uſe of the foregoing Tables, *collected from Mr.* S. NEWTON's Idea. Geogr. & Nautic.

Firſt, You muſt have in readineſs a Teleſcope Twelve or Fourteen Foot long; which directed to *Jupiter*, will ſhew his *Satelites*; which otherwiſe, are inconſpicuous to moſt Men.

2. This Table it ſelf ſhews you all the Eclipſes of the Four *Satelites*, for every Month of the Year; and upon what Day of the Month, and Hour and Minute of the Day each Eclipſe happens.

The Letter E, ſignifies the Emerſion or End of the Eclipſe; and I, the Immerſion or beginning thereof.

Thus in the firſt Table againſt *September* 26, you find 13 H. 57 M. and in the Reſponding *Satelite* Column, you find 4 $\left\{\begin{matrix}\text{I.}\\\text{E.}\end{matrix}\right.$ The meaning whereof is, that upon *September* the 26th, at 13 Hours 57 Minutes, Afternoon, the 4th *Satellite* Immergeth or Entreth the Shadow of *Jupiter*; and conſequently the Eclipſe endeth. Alſo againſt *December* 2. ſtands 11 H. 10 M. I. which ſhews, tht the Firſt *Satelite* Immergeth or beginneth to be Eclipſed that Day at 11 H. 10 m. Afternoon. And upon *December* 30th. the Table ſhews you, the ſame Firſt *Satelite* Emergeth, or ceaſeth to be Eclipſed, at 18 H. 33 M. Afternoon.

The Eclipſes in theſe Tables, are ſuch as are Viſible in *England*: But to find when any other Eclipſe, not Viſible to us, but under ſome remote Meridian, happens; you muſt firſt take the Mean Revolutions of the *Satelites*: Then to find when the next Eclipſe of the Firſt *Satelite*, &c. will happen after October 1694. you muſt do thus:

To the given Time of the Catalogue (or Second Table) for *October* the 4th, *viz.* 15 H. 54 M. add the Time of one Revolution or Circuit, *viz.* 1 D. 18 H. 28′. 36″. the Sum is 2 D. 14 H. 22′. 36″. which add to *October* the 6 D. 14 H. 22′. 36″. *viz.* the Time of the next Immerſion; and thus you may proceed for all the reſt: And by the help of a Terreſtrial Globe, rectify'd for the Latitude of *London*, and to the Day of the Month; you may find where any other Immerſion or Emerſion will be Viſible.

Thus having ſhewn the Uſe of theſe Tables of the Eclipſes of the *Satelites* of *Jupiter*; you muſt have ready (as was ſaid before) for Uſe, a Tube or Teleſcope Twelve or Fourteen Foot long directed to him to diſcover theſe his Attendants; otherwiſe, they are not diſcernable by the naked Eye. Therefore, at the Time of Obſervation, which muſt be

be always when some or other of *Jupiter's Satelites* are Eclips'd; you must find the true Time of the Night, either by the Altitude of a Star in any Azimuth, or by any Stars coming on the Meridian at that Time.

Then by comparing the Time between the Merid. for which the foregoing Tables were calculated, and that which you find either by the Culmination of any Star, or its Altitude upon any other Azimuth; you may attain the Difference of Time between these Two Meridians; which Difference of Time, proceed with as directed in the first *Method.*

Note, In the foregoing Table of *Jupiter's Satelites*, calculated *Anno* 1694. you are to observe, the Eclipses of the First *Satelite* are the most convenient for determining the Longitudes of Places; not only because they happen more frequently, and may be distinctly seen with a good Telescope, Eight, Ten or Twelve Foot long; but also, because its Motion is found more Regular.

Also the *Satelites* of *Jupiter* having no sensible Parallax with the Earth, in every Position of *Jupiter* above the Horizon, they are conveniently observ'd.

Example.

Admit in a Ship at Sea, (or on some unknown Island, I were on Shore) *October* the 8th. I find by my Telescope, that the Immersion of the First *Satelite* is at 3 a-Clock, 48 Minutes past, in the Morning; *viz.* by an accurate Observation taken, of some known Star's Altitude, (or when a Star was upon the Meridian:) But by the foregoing Table for 1694. I find the Immersion to be at 14 Hours 41 Minutes, or 2 H. 41 M. Therefore from the observed Time, 3 H, 48 M.

	H.	*H.*	*M.*
Adding 12	—	—	15 : 48
Substract the Tabular Time		—	14 : 41
The Remainder is	—	—	1 : 07

Which Reduced to Time thus;

H.	*M.*	
1.	07.	
	5	Multiply by the Ratio of 15. *viz.* 5 and 3.
5 :	35	
	3	
	16 :	45

The Difference of Longitude between the Meridian of the Ship, (or Place) and that of the Place for whose Meridian the Table was calculated.

As

As to this *Third Method*, by the Eclipſes of *Jupiter's Planets*, this muſt be own'd of much greater Uſe; ſince the Quickneſs of their Motion, eſpecially as to the Firſt or Innermoſt, makes the Moment of their Immerſion into, or Emerſion from *Jupiter's* Shadow very diſtinct and nice; and their Frequency, which is almoſt one for every Day, render them fit for the conſtant Uſes of Navigation. Nor have we any Method ſo uſeful to diſcover the Longitude at Land, as this. Yet this Method labours under Difficulties ſcarce to be remedy'd: *viz.* 1. The beſt Tables of their Motions, for want of a ſufficient Number of Obſervations, are not arriv'd to their deſir'd Perfection; to be at all Times depended on, to be put in Practice. 2. The Difficulty, if not Impoſſibility of finding true Time at Sea. 3. The Improbability of managing a Teleſcope of Ten, Twelve, or Fourteen Foot long, that State of Toſſing, Agitation, and Rowling Motion of a Ship at Sea. 4. The Impoſſibility of ſeeing theſe Eclipſes, for about Three Months every Year, when the Planet *Jupiter* is near the Rays of the Sun; or when he is below the Horizon; renders this Method, at preſent, but of ſmall Uſe in Navigation.

METHOD IV.

To find the Longitude of any Place by Automata's, *or Unerring-Clocks, Watches, or Hour-Glaſſes.*

Firſt, BY Sand-Glaſſes: You are to prepare a very perfect and true Running-Glaſs, which may preciſely run 24 Hours without Error. And at the Time you ſet ſail from the Land, ſet the Glaſs a-running that Day, juſt at Twelve a-Clock at Noon, when the Sun is upon the Meridian: Being run out, be ſure to turn the ſaid Glaſs inſtantly as it is out, not loſing any Time in the Turning of it. And ſo having very warily kept the ſaid Glaſs, till you think good to make an Obſervation; at which Time, it is requiſite to have in readineſs, an Half Hour, Minute, and Half Minute-Glaſs; that if the 24 Hour-Glaſs be out, before the Sun comes to the Meridian, then ſo ſoon as it is out, to turn the Half Hour, Minute, or Half Minute-Glaſs, as you ſee occaſion; thereby to know exactly how much the 24 Hour-Glaſs is out, before the Sun comes to the Meridian: For if the Sun is upon the Meridian, juſt when the 24 Hour-Glaſs is out, then you may aſſure your ſelf you have ſail'd North or South, and are ſtill under the ſame Meridian you were at firſt:

But

But if the 24 Hour-Glaſs be out, before the Sun comes to the Meridian, for every Four Minutes that the Glaſs is out before Noon, your Difference of Longitude is 1 Degree to the Weſtward; and for every Hour 15 Degrees: And contrary, if the Sun comes to the Meridian before the Glaſs is out; then according to the ſame Proportion of Time, is your Difference of Longitude to the Eaſtward of the Meridian you departed from.

Secondly, By a Good Watch, that hath been obſerv'd a-ſhore to keep a True and Equal Motion: But here we muſt obſerve, that if the Watch be never ſo exactly made, yet it will not keep equal Pace with the Sun, or a True Sun-Dial; but go Faſter or Slower, according to the following Table of Equation of Time.

The Uſe of this Table is very plain; for find the Month at the Top of it, and the Day of the Month at the Left Hand, and in the common Angle of meeting, You have the Equation in Minutes and Seconds, whether it be too Faſt or too Slow, as the Title (*Watch too Faſt*,) or *Watch too ſlow*) directs. Therefore, if you ſet your Watch or Clock exactly with the Sun, when the Equation is Nothing, (as on the Sixth of *June*,) it will after that always hold the ſame Equation found in the Table, whether too Faſt or too Slow: And the Quantity (if your Watch go right;) and ſo likewiſe at any Time, if you ſet your Watch when there is Equation; you muſt give it the Equation anſwering to that Mouth and Day, (whether too Faſt or too Slow) and then it will alſo hold the ſame Equation: For a Good Watch or Clock divides Time equally; but the Sun, by Reaſon of ſome Inequality in his Motion, divides the Time unequally: So that if the Sun, and a true going Watch, be Set together at ſome Times in the Year, yet the ſaid Watch will ſometimes differ 10, 12, nay ſometimes 16 Minutes from the Time given by the Sun; and yet no Fault in the Watch (as beforeſaid.) This Table will ſerve for many Years, without any ſenſible Alteration: And for the Reaſons of the Sun's Inequality of Motion, and the Equation of Time, I have not room here to explicate; but refer the Reader to my *Speculative Aſtronomy*, in the *Engliſh Academy*.

Days

Days	January		Februa.		March		April.		May.		June.	
	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.
1	9	4	14	48	10	4	0	45	4	10	1	2
2	9	26	14	46	9	47	0	28	4	11	0	50
3	9	48	14	44	9	30	0	12	4	12	0	37
4	10	10	14	41	9	13	0	3	4	13	0	25
5	10	31	14	37	8	55	0	18	4	12	0	1
6	10	51	14	32	8	37	0	33	4	11	0	0
7	11	9	14	27	8	19	0	48	4	10	0	13
8	11	27	14	21	8	1	1	2	4	8	0	26
9	11	45	14	15	7	43	1	16	4	6	0	39
10	12	2	14	7	7	25	1	28	4	3	0	52
11	12	18	13	59	7	6	1	41	4	0	1	4
12	13	34	13	50	6	47	1	54	3	56	1	17
13	13	47	13	41	6	28	2	6	3	51	1	30
14	13	2	13	31	6	10	2	16	3	46	1	43
15	13	15	13	21	5	51	2	27	3	40	1	56
16	13	27	13	10	5	32	2	38	3	34	2	8
17	13	38	12	59	5	14	2	48	3	28	2	32
18	13	48	12	47	4	55	2	57	3	21	2	44
19	13	58	12	25	4	36	3	6	3	13	2	56
20	14	7	12	22	4	17	3	14	3	5	3	7
21	14	15	12	8	3	50	3	22	2	56	3	19
22	14	22	11	54	3	40	3	30	2	48	3	30
23	14	28	11	40	3	22	3	37	2	39	3	41
24	14	34	11	24	3	3	3	43	2	29	3	51
25	14	38	11	9	2	45	3	49	2	19	4	1
26	14	42	10	54	2	26	3	53	2	9	4	11
27	14	45	10	38	2	9	3	57	1	59	4	21
28	14	47	10	21	1	51	4	01	1	48	4	29
29	14	48			1	34	4	4	1	37	4	37
30	14	49			1	17	4	7	1	25	4	43
31	14	49			1	1			1	14		

Watch too Fast. Watch too Fast. Watch too Fast. Watch too Slow. Watch too Slow. Watch too Fast.

Days.	July.		Aug.		Sept.		Octob.		Nov.		Dec.	
	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.
1	4	45	4	28	3	53	13	18	15	21	5	35
2	4	53	4	18	4	14	13	32	15	13	5	06
3	5	0	4	8	4	34	13	46	15	03	4	38
4	5	7	3	57	4	55	13	59	14	53	4	09
5	5	13	3	47	5	15	14	11	14	41	3	40
6	5	18	3	37	5	36	14	23	14	29	3	10
7	5	24	3	27	5	56	14	34	14	17	2	40
8	5	29	3	8	6	17	14	44	14	03	2	10
9	5	33	2	55	6	38	14	54	13	49	1	40
10	5	36	2	42	6	58	15	04	13	34	1	11
11	5	39	2	27	7	19	15	13	13	17	0	41
12	5	42	2	13	7	39	15	22	13	00	0	11
13	5	44	1	58	7	59	15	28	12	43	0	19
14	5	45	1	42	8	19	15	34	12	24	0	49
15	5	46	1	26	8	38	15	40	12	05	1	19
16	5	46	1	9	8	58	15	45	11	45	1	49
17	5	45	0	52	9	18	15	50	11	25	2	18
18	5	42	0	35	9	37	15	53	11	04	2	47
19	5	40	0	17	9	57	15	56	10	42	3	16
20	5	38	0	1	10	16	15	58	10	20	3	45
21	5	34	0	18	10	34	15	59	9	56	4	14
22	5	30	0	36	10	52	16	01	9	32	4	42
23	5	26	0	55	11	10	16	00	9	08	5	09
24	5	20	1	14	11	28	15	59	8	43	5	36
25	5	14	1	34	11	45	15	57	8	17	6	04
26	5	8	1	53	12	02	15	54	7	51	6	30
27	5	2	2	12	12	18	15	51	7	25	6	57
28	4	52	2	32	12	33	15	47	6	59	7	24
29	4	46	2	52	12	49	15	41	6	32	7	48
30	4	35	3	13	13	04	15	35	6	03	8	12
31	4	32	3	33			15	29			8	37

Too Fast. Too Fast. Too Slow. Too Slow. Too Slow. Too Slow. Too Fast. Too Slow. Watch too Slow.

The

The Uſe of this Table, as to determining the Difference of Longitude, is thus; Being provided with a good Watch, that you know by Experience to have kept a True and Equal Motion on Shore; when you ſet Sail or depart from the Land, obſerve in the Table of Equation of Time, how much the Watch is too Faſt or too Slow; and ſet your Watch to it, as before directed, and not to the Time of the Day by the Sun, unleſs it be when the Equation is Nothing, As for Example:

Suppoſe I ſail from any Port upon a Voyage, upon the 27th of *November*, when the Equation in the Table is 7 M. 25 Seconds, and the Title *Watch too Slow*: I conclude from thence, that a good Watch ſhould be 7 M. 25 S. too Slow, or behind the Time given by a true Sun-Dial. Therefore I put my Watch 7 M. 25 S. behind the Time given by the Sun; as ſuppoſe I ſet my Watch at 12 a-Clock, I put it 52 M. 35 S. paſt 11 a-Clock. And then provide a little Square or Round Box of about Four or Five Inches Broad; and having it fill'd with Fine Cotton, taking part of the Cotton out, and putting the Watch in the Middle of the Box, upon the Cotton you leave in the Box; and put the reſt you took out, upon the Watch cloſely; and ſhut the Box, keeping it in ſome Dry Place, as in your Cabbin, or upon ſome Shelf near your Bed: And this to hinder the Alteration of Air, in different Climates, from having any Effect on the Movement, to cauſe it to go faſter or ſlower. Then, ſuppoſing you have ſailed Eaſtward, your Watch will want ſomething of Twelve a-Clock; if Weſterly, it will be more than Twelve by the Watch. Admit then I find the Sun juſt upon the Meridian; and find by my Watch it is 16 m. 15″. after 2 a-Clock, and looking in the Equation-Table for the Day of the Month, (ſuppoſe *Feb.* 18.) I find my Watch too Faſt 12 M. 47 S. Therefore Subſtract 12 M. 47 S. from the Time given by the Watch 2 H. 16 M. 15″. the Remainder 2 H. 3 M. 28″. Reduced as in the Firſt Method, gives 30°. 51′. the Difference of Long. but if it had been too Slow 12′. 47″. you muſt have added 12′. 47″. to 2 H. 16′. 15″. the Sum 2 H. 29′. 02″. would give the Difference of Longitude, *viz.* 37°. 15½′. 'Tis thought, that if this Method was carefully put in practice, by our Commanders, *&c.* at Sea, it would render the Buſineſs of Longitude practicable; but we would adviſe, not to confide ſo much therein, as to omit any of the Methods of a *Journal*, or uſual Precautions to preſerve a Ship, when ſhe approaches near Land.

METHOD V.

To find the Longitude of any Place, by the Appulſes and Occultations of the fixed Stars by the Moon. See Dr. *Halley*'s Appendix, to Mr. *Street*'s *Aſtro Carol.*

There have been other *Methods* for the Diſcovery of Longitude; as,

METHOD VI.

THE Variation of the Needle from the North, is now, eſpecially ſince Dr. *Halley*'s notable Obſervations, and Map thereto relating, become one Method for this Purpoſe: Particularly in thoſe Parts where the Variation is beſt known; and the North and South Poſition of its Lines are moſt remarkable. For by croſſing the Meridians, there you alſo croſs the *Curves* of Equal Variations, and diſcover in ſome meaſure your Longitude thereby.

But in this Caſe alſo, the Curve-Lines of the Variation of the Needle, are of ſmall uſe; becauſe the Laws of that Variation, are not yet brought to a ſufficient certainty; notwithſtanding the moſt uſeful Endeavours of Dr. *Halley* in that Matter. The Neighbourhood of Iron Mines, of Iron, or of Loadſtones themſelves, do ſometimes diſturb the General Rules, and deceive the Obſervers of that Variation. The Poſition of thoſe Curves too far Eaſtward or Weſtward, in a great part of the World, renders this Variation uſeleſs, as to any general Diſcovery of the Longitude. And even there, where the Poſition of thoſe Curves is the moſt Advantageous; as it is about the *Cape of Good Hope*, and a conſiderable Way on both Sides of it; yet is the Diſtance of thoſe Curves, for the Difference of One Degree of Variation, about 100 Geographical Miles, *i. e.* near 2 Degrees of a great Circle: And ſo this *Method*, (as well as the others) as yet, is incapable of Longitude very nicely in any Caſe whatſoever.

Yet this Method may be greatly improved, by the Contrivance of the Ingenious Mr. *Whiſton*, in his excellent Diſcovery of the Magnetical Variation of the Needle.

VII. Another *Method* hath been propos'd for this purpoſe, by certain fixed Stars, choſen for each Time of the Year, *&c.* but is altogether abſurd, as might be eaſily prov'd, had I room.

VIII. Another to explicate a New *Method* for finding the Longitude, propoſes a new *Theory* of a Threefold Motion of the Earth: *viz.* 1. From Weſt to Eaſt call'd the *Diurnal*, making its Revolution about its own *Axis* in 24 Hours. The 2d.

3d its Motion towards the North, 23° ½. one Half of the Year; and the 3d. its Motion towards the South 23° ½. the other Half Year.

IX. Mr. *Whiſton*, M.A. and *Humphrey Ditton*, Math. preſents us with another Method for the Diſcovery of Longitude, from the Exploſion of Sounds of Great Guns, from Stationary Ships, Buoys or Marks in the Sea, at ſuch a Diſtance from each other; and of Bombs or Fireworks being fir'd up, *&c.* But I ſhall wave theſe, and leave it to the Authors to try their own Experiments, if they pleaſe.

Laſtly, The laſt Method I ſhall mention, is that of Mr. *W. Blundell*, by his Circles of Reverſion, inverting the Mariner's Compaſs, from North to South, and from South to North, *&c.* For which I refer the Reader to his Book in *Folio*, which he hath plentifully ſpread abroad, *gratis*; having not room to enlarge here.

An ESSAY *to find the Annual Variation of the Needle, at all Times, all Seaſons, and all Places or Latitudes.*

DEFINITION.

THE Declination or Variation of the Needle is uſually obſerv'd by Mathematicians and Mariners, by comparing the Azimuth of the Sun with the Diſtance of the Needle from the North or South Points of the Meridian; but erroneouſly, by Reaſon that the Needle continuing its ſtanding, and the Sun's Azimuth altering every Minute of the Day; the Variation, or Difference of the Azimuth of the Needle from the Sun's, cannot be at all Times alike: And therefore, the Variation of the Needle in the Compaſs, not truly to be found by this Method.

On which Conſideration, we judge, that there could be no ſufficient Proof of the Needle's Variation, unleſs by a due length of Time or Annual, ſuch an Equation were found betwixt the Standing of the Needle, and Azimuths caus'd by the Sun's Motion in the Ecliptick; whereby might be demonſtrated the Variation of the Needle.

To which purpoſe, the Honourable *Edward Howard* made Obſervations on both Sides of the Wall that ſurrounds *Windſor*-Caſtle, not conſiderable different: He found the Needle to Point at 13°. and to find its Annual Variation in both theſe Places, he gives us this ſubſequent *Theorem* thus worded.

THEO-

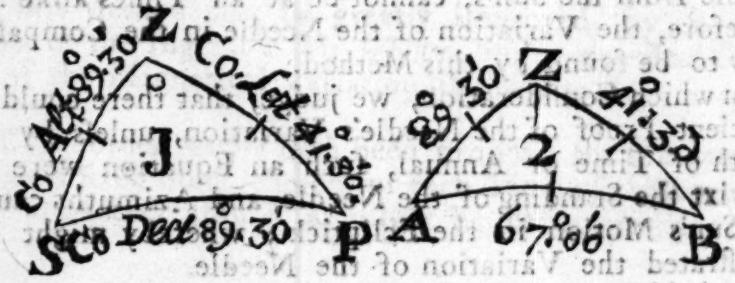
THEOREM.

IF betwixt the Sun's Declination of 30 Minutes from the Equator; as alſo, his Altitude 30 Minutes (or leſs if need be thought neceſſary) be taken, the mean Proportional Sine, betwixt his Azimuth at 30 Minutes Declination, and Altitude, and the Standing of the Magnetical Azimuth; and next that, the ſame be done from his greateſt Declination, wanting 30 Minutes, and 30 Minutes of Altitude; and the Difference taken betwixt both the Mean Proportionals ſo found: It is probably the moſt certain Way to find the Variation of the Compaſs in any Place; for all Times and Seaſons of the Year in any given Latitude.

To render the more practicable the great Publick Uſe of the Compaſs at Sea, and whereby may be demonſtrably avoided and detected, the common Errors incident to Navigation, as uſually obſerv'd in the Variation of the Compaſs, in Voyages on the Ocean: Let us apply the precedent *Theorem.*

PROB. II.

Suppoſe a Ship ſails from *Portland* in *England*, in Lat. 50°. 30'. N. to *Lisbon* in *Portugal*, in the Lat. of 38°. 45'. N. and it were requir'd to find the Variation for every 2°. of Lat. in the Voyage, the Diff. of Lat. is 11°. 45'. There is conſtantly given the leaſt Altitude and leaſt Declination each 30 Min. as alſo the Sun's greateſt Declination wanting 30 M. and leaſt Altitude 30 Min. which you may reſolve, with Application to the pointing of the Needle, by theſe Two Spherical Triangles, *viz.*



In the Firſt Triangle is given Complement of the Lat. found at Sea, *i.e.* PZ. = 41°. 30'. the Comp. of 30'. of Altitude, Z.S. the Comp. of 30'. of Declination to 90°. S.P. To find SZP. the Sun's Azimuth by the 19th. *Prob.* of *Aſtronomy* foregoing,

is

is = 89°. 50′. whoſe Sine is — 9. 9999981
And the Azimuth in the Needle, we will ſuppoſe to be 13°. whoſe Sine is } 9. 3520880

Their Multiplication — 19. 3520861

Their Half, and Mean Proportional 28°. 18′. ½ — 9. 6760430

For the Firſt Operation in the Triangle S Z P.

In the Second Triangle A Z B, the Azimuth will be found to be = 54°. 34′. whoſe Log. Sine is 9. 9110460
Azimuth of the Needle as before 13°. Sine 9. 3520880

Their Multiplication — 19. 2631340.

The Half, and Mean Proportional, is 25°. 50′. | 9. 6315670
Firſt Mean Proportional Subt. 28 : 18 |

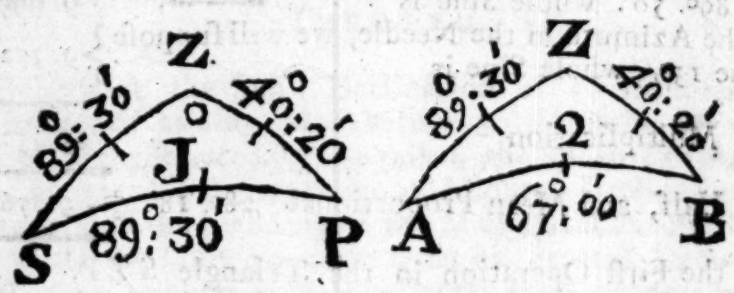
Variation — 2 : 28 for the 1 Quarter of the Ecliptick, in Lat. 48°. 30′. That is, when the Ship was in Lat. 48°. 30′. N. the certain Variation of the Compaſs was for one Quarter of the Ecliptick; which includes all the Varieties of the Sun's Annual Motion: The Needle being ſuppos'd to point as permanent at Sea, as it is obſerv'd on Land, *&c.*

By this manner of Triangular Solution, there were no hard Labour to prepare a Table beforehand, in which might be inſerted all the Azimuths for every 2 Deg. of the Diff. of Lat. decreaſing to the 11°. 45′. as the Ship ſails from *Portland*; and alſo by the ſame Method for the laſt 1°. 45′. which compleats all the Azimuths to the Port of *Lisbon*: There being nothing more requir'd, than carefully to obſerve the Latitudes in ſailing, which moſt knowing Mariners can dexterouſly perform.

EXAMPLE II.

IN Lat. 49°. 40′. Magnetical Azimuth 8°. What's the Annual Variation?

In



In the Triangle S Z P, is given S P 89°. 30'. S Z. 89°. 30', and Z P 40°. 20'. to find the ∠ S Z P, which is = 89°. 50'.

The Sun's Azimuth 89°. 50'.	Sine	9.9999981
Magnetical Azimuth 8°. 00'.	Sine	9.1435555
	Z is	19.1435536
First Mean Proportional = 21°. 54'.		9.5717768

In the Second Triangle A Z B, the Azimuth of the Sun at greateſt Declin. wanting 30'. and Altit. 30'. is S. 9.9057386

Magnetical Azimuth 8°.	S.	9.1435555
	Z is	19.0492941
Half and Mean Proportional, is = 19°. 33.		9.5246470

Then firſt Mean Proportional, is	21°: 54'.
Second Mean Proportional, is	19 : 33
Variation —	2 : 21

At 49°. 40'. N. Lat. for 1 Quarter of the Ecliptick, that is, 2°. 21'. X 4 = 9°. 24'. Variation in that Lat. and the Needle ſtood at 8 Deg. according to Dr. *Halley*'s Chart.

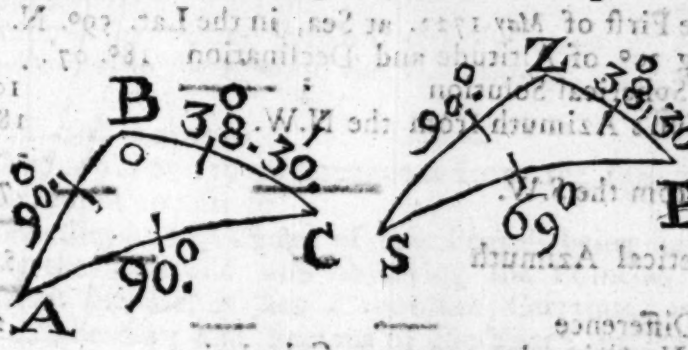
By this Proceſs, ſuitable to the *Theorem*, if obſerved from 2 Deg. *x*. Lat. or as often as Opportunity may be had, from the Port whence the Ship ſail'd from, to the End of the Voyage at Sea; the Courſe will be directed more commodiouſly certain, and leſs expenſive to Trade and Commerce, *&c.* with a further Improvement of that excellent, ſecret, and great guide of Navigation, the Compaſs.

For further apprehending the erroneous Method of Calculation, vulgarly uſed at Sea, in finding the Magnetical Variation, compar'd with the Amplitude, Ortive or Occaſive, or Azimuth of the Sun.

As

As to Amplitudes commonly obſerv'd at Sea; one Exam- may ſuffice inſtead of more.

In Lat. 51°. 30'. N. The Sun having 21°. Declination N. the Magnetical Amplitude, obſerv'd at Sun-ſetting, was 49°. from the North, Weſtward. According to the Proceſs in theſe Two Triangles hereunder: In the Firſt, the Sun having no Altitude at Setting, I take for the Side A B a Quadrant, or 90°. as alſo the Side A C 90°. repreſenting the whole Quadrant of the Ecliptick, or Diſtance of the Pole C to A, the Place of Sun in the Ecliptick, in the Triangle A B C.



By Solution of which Triangles, I find the Firſt Mean Proportional Sine — — — 53°: 48'.

And of the Triangle S Z P, I find the Second Mean Proportional Sine. — — } 47 : 05

Their Difference — — — 6 : 43

And true Magnetical Variation from the Amplitude found, or the ſame with the Azimuth, the Sun having no Altitude, which is 6°. 43'. That is, the North-Point of the Magnetical Amplitude, declines from the true North, or Interſection of the Meridian and Horizon 6°. 43'. towards the Weſt.

Whereas, by uſual Computation at Sea, the Magnetical being — — — — 49° : 00.

The Amplitude found would be — — 35 : 08

Variation — — — — 13 : 52

Variation *per* Theorem — — — 6 : 43

The Difference is — — — 6 : 69

So conſiderable an Error is committed in the ordinary Calculation of Navigators by Amplitudes, which evidently is ſuch, in not computing the True Variation inſtead of the Apparent of the Magnetical; according to this Proceſs or Theorem.

Note, That after Sun-rising, the Calculation being made by the *Theorem*, the Azimuth and Variation would be the same for that Day, whilst the Lat. had no considerable Alteration; which by common Observation at Sea, would have an erroneous Difference. The like may be found in the usual Observations of the Magnetical Azimuths on the Ocean, compar'd with the Sun's: Of which I shall represent to any impartial Judge,

EXAMPLE I.

The First of *May* 1723. at Sea, in the Lat. 59°. N. the Sun having 30°. of Altitude and Declination 18°. 07'.

By Spherical Solution	105°. 20'.
The Sun's Azimuth from the N.W.	180 : 00
And from the S.W.	74 : 40
Magnetical Azimuth	53 : 30
The Difference	21 : 10
is the Variation by common Calculation.	
By the Process in the *Theorem*, the Variation is found	21°: 10'. / 16 : 34
Erroneously sail'd according to the usual Calculation of Mariners.	4 : 36

EXAMPLE II.

IF on the same Day the Altitude of the Sun had been but 20°. when the Lat. and Declination of the Sun could have no considerable Alteration: Then the Azimuth observ'd from the N. or S. Westward, by common Observation at Sea, would be — 88°: 04'.

The Magnetical as before Standing	53 : 30
Difference would be in the Variation	34 : 34
By the Process in the *Theorem*, it is but	16 : 30
Which proves the Error to be	18 : 04

Such a vast Erroneous Difference in a Maritime Voyage, is only to be avoided by the certain Operation of the precedent *Theorem*.

EXAM-

EXAMPLE III.

MAY 9th, 1723. before Noon in Lat. 58°. North, the Sun having 32°. of Altitude, and Declination 19°. 59'. the Magnetical Azimuth was 53°. from the South Eastward.

By common Observation, the Sun's Azimuth from the N. Westward	}	108° : 14'. 180 : 00
And therefore from the S. Westward		71 : 46
Magnetical Azimuth		53 : 00
By common Observation the Diff. and Variation		18 : 46
By the Process in the *Theorem*, the Variation is		14 : 27
The Diff. and Error is		4 : 19

That is 4°. 19'. or 259 m. erroneous from the Proper Coast the Ship ought to sail to.

The Facility and Exactness of this Process being such, that knowing the Latitude, and observing the Pointing of the Magnetical Needle, it has a requisite Certainty, as to all Times of the Day and Seasons of the Year; including by the Magnetical Variation found, all the Mean Proportional Azimuths, infinitely Increasing and Decreasing to a Quarter of the Ecliptick, betwixt the Standing of the Needle, and Course of the Sun, as before mention'd, which implies all the Varieties of his Annual *Phænomena*'s and Azimuths to that purpose; and is the most Commodious and Practical Proof of the Doctrine of *Fluxions*, much improv'd by our Famous Sir *Isaac Newton*, that I believe is as yet understood.

All which Examples, we hope, may be acceptable to the Science of such of the Learned that are zealous for the Publick Good, and Improvement of the Noble *Art of Navigation*, &c. To whom I wish, Prosperity may attend their Sails and Laudable Undertakings.

A Ship's Tackling describ'd.

See Plate 3d. *The Draught of a Ship.*

The { 1 Ensign. / 2 Mizen-vane. / 3 Mizen-top-sail. / 4 Mizen-top-sail-yard.

The { 5 Cross-jack-yard. / 6 Mizen-yard. / 7 Main-vane. / 8 Main-pendant.

The

9 Main-top-gallant-ſail. h
10 Main-top-ſail. k
11 Main-ſail. l
12 Fore-vane. n
13 Fore-top-gallant-ſail. m
14 Fore-top-ſail. o
15 Fore-ſail. r
16 Jack. s
17 Sprit-ſail-top-ſail. t
18 Sprit-ſail. u
19 Fore-top-gallant-ſtay.
20 Fore-top-gallant-bowlines a
21 Fore-top-maſt-ſtay. b
22 Fore-top-ſail-bowlines. c
23 Crane-line. d
24 Fore-ſtay. e
25 Main-ſtay. f
26 Main-top-maſt-ſtay. g
27 Main-top-gallant-ſtay. h
28 Main topgallant bowlines k
29 Fore-top-gallant-braces. l
30 Fore-top-ſail-braces. n
31 Main-top-ſail-bowline. m
32 Galleries. o
33 Poop-Lanthorn. p
34 Main-top-ſail-brace. q
a Mizen-Maſt. r
b Main-maſt. s
c Fore-maſt. t
d Bow-ſprit. u
e Mizen-top-ſail-lifts. x
f Mizen-crow-foot.
g Hoiſting-line for a Flag or Pendant. a b
h Mizen-ſheet. c
a Mizen-top-maſt. d
b Mizen-top-ſail-brace. e
c Mizen-top-ſail-clew line f
d Mizen-top-ſail-ſheet.

Main-Maſt. g

a Main-top-gallant-maſt. h
b Main-top-gallant-lifts. l
c Main-top-gallant-yard.
d Main top-gallant-braces m
e Main-top-maſt. n
f Main-top-maſt-back-ſtay o
g Main-top-ſail-lifts. n

The

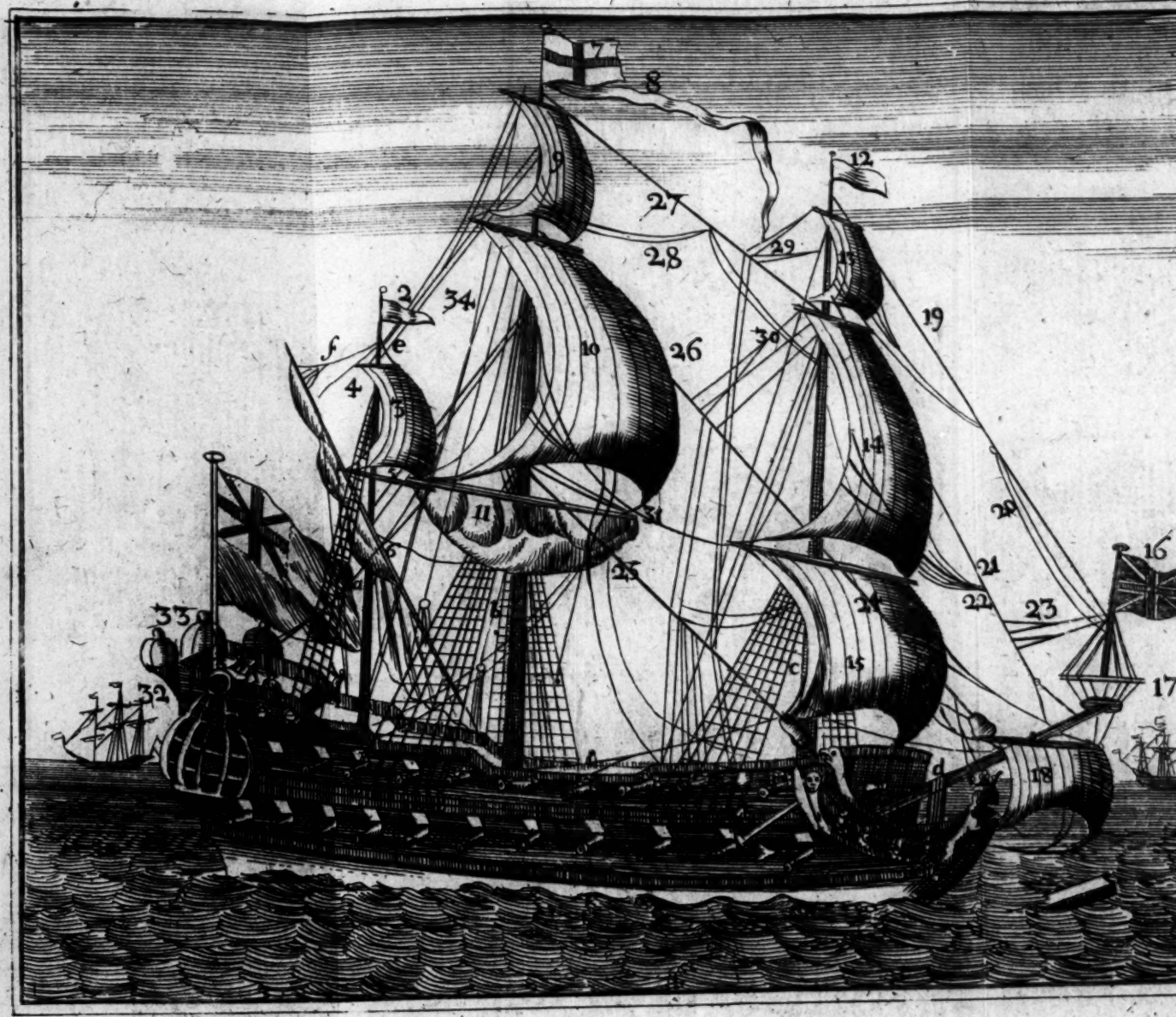
Main top-ſail-braces.
Main-top-ſail-clew-line
Main-topſail leatch-line
Main-top-ſail-bunt-line
Main-lifts.
Main-yards.
Main-braces.
Main-ſheets.
Main-tacks.
Main-ſhrouds.

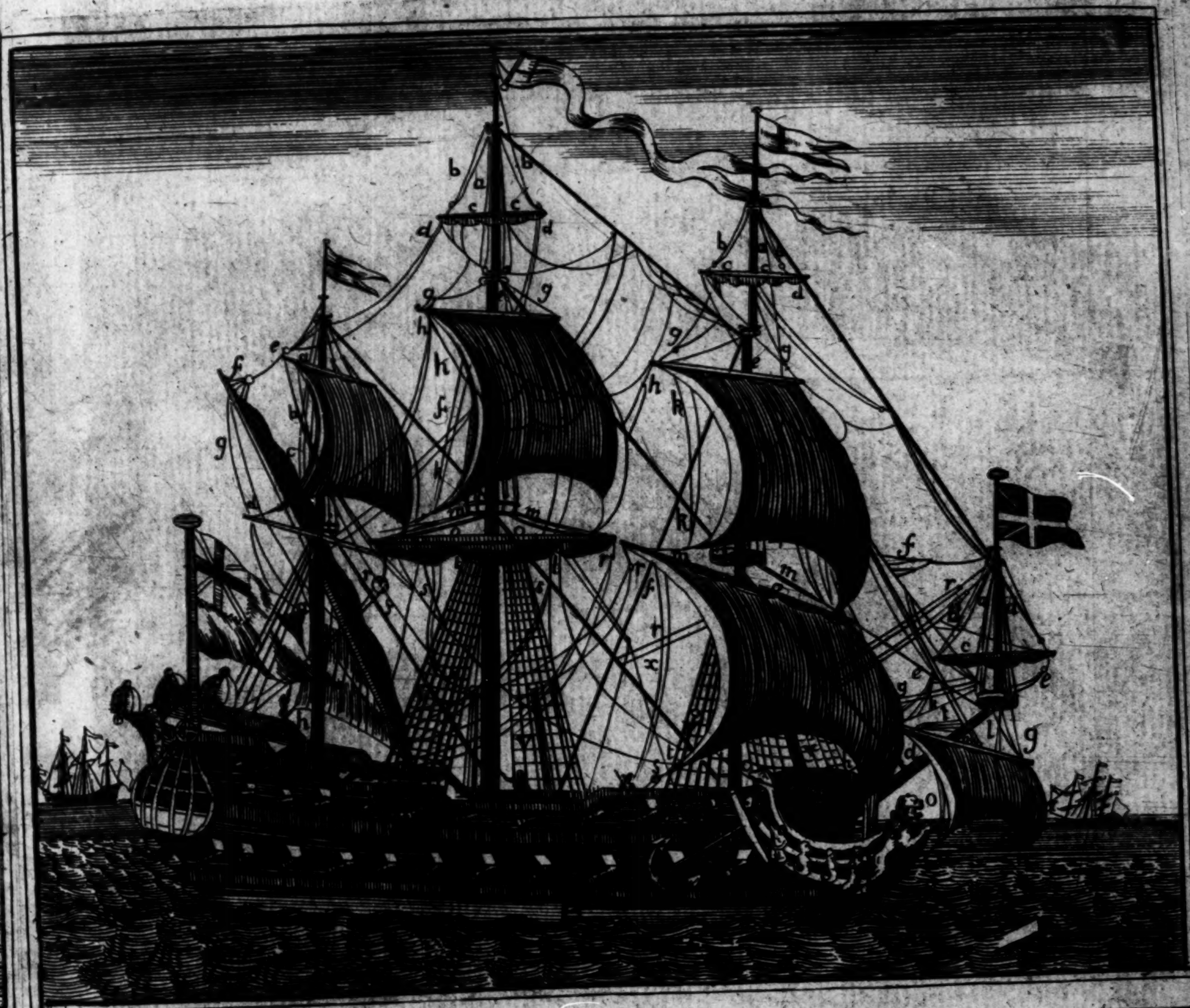
Fore-Maſt.

Fore-top-gallant-maſt.
Fore-top-gallant-lifts.
Fore-top-gallant-yard.
Fore-top-gallant-braces.
Fore-top-maſt.
Fore-top-maſt-back-ſtay.
Fore-top-ſail-lifts.
Fore-top-ſail-braces.
Fore-top ſail-clew-line
Fore-top-ſail-leatch-line
Fore-top-ſail-bunt-line
Fore-lifts.
Fore-yard.
Fore-leatch-lines.
Fore-bunt-lines.
Fore-braces.
Fore-ſheets.
Fore-tacks.
Fore-ſhrouds.
Fore-clew-garnet.

Bow-Sprit.

Sprit-ſail-top-maſt.
Sprit-ſail-top-ſail-lifts
Sprit-ſail-top-ſail-yard
Spritſail-top-maſt-ſhrou
Sprit-ſail-top-ſail-brac
Sprit-ſail-top-ſail-crow-foot.
Sprit-ſail-top ſail-ſheet
Horſe on the bow-ſprit
Standing-lifts for ſpri ſail-yard.
Sprit-ſail-yard.
Sprit-ſail-ſheets.
Sprit-ſail-clew-lines.
Crean-line.


8
9
12
27
28
29
2
34
19
f
e
10
26
30
4
14
11
31
29
16
21
25
22
23
33
24
15
c
17
32
d
18



P 4

p

The Young Seaman's DICTIONARY,

OR,

An Explanation of the moſt Uſual SEA-TERMS.

In an Alphabetical Order.

A.

AFT or *Abaſt*, towards the Stern of the Ship, as the Maſt hangs aft: That is, towards the Stern.

How chear ye fore and aft? That is, how fares all your Ship's Company.

Amain; a Word us'd by a Man of War to his Enemy, and ſignifies to Yield.

Strike Amain; that is, lower your Top-ſails.

The Anchor is a-Peek, viz. Right under the Ship's Bow or Hawſe-Hole.

The Anchor is a-Cock-bell; that is, hangs up and down by the Ship-ſide.

The Anchor is foul; that is, the Cable is got about the Fluke.

An Awning; a Sail or the like, ſupported like a Canopy over the Deck, to prevent the ſcorching Heat of the Sun in Hot Climates.

B.

TO *Bale*; to lade Water out of the Ship's Hold, with Buckets or the like.

Trench the Ballaſt; divide or ſeparate it.

The Ballaſt ſhoots; that is, it runs over from one ſide to the other.

To Bear in with the Land, &c. to ſail towards it.

To bear in; that is, to ſail before or with a Wind, into a Harbour or Channel.

A piece of Ordnance (or great Gun) doth come to Bear; that is, lies right with the Mark.

Bear up; a Term us'd in Conding the Ship, when they would have her ſail more before the Wind.

Bear up around; put her right before the Wind.

To Belage; to make faſt any running Rope.

To Beleend a Cable, is to clench or make it faſt to the Ring of the Anchor.

A Birth; a convenient Place for a Ship to Moor or Ride at Anchor in.

A Bight; any Part of a Rope between the End, when doubled together.

The Bilge; the Breadth of the Place the Ship reſts on, when ſhe is a-ground.

The Ship is Bilged; that is, has ſtruck off ſome of her Keel, Timber, or bottom Planks on a Rock or an Anchor, and ſprings a Leak.

A Binnacle; that wherein the Compaſs ſtands.

A Bitter; a turn of a Cable about the Bitts.

The Bitts; Two great Square Pieces of Timber, to which the Cables are faſten'd, when the Ship rides at Anchor.

A Boom; a long Pole us'd to ſpread out the Clue of the ſcudding Sail, *&c.*

Board and Board; a Term uſed when Two Ships come ſo near as to touch one another.

To make a-Board, or *Board it up*, is to turn to Windward.

To break Bulk, is to open the Hold, and take out Goods thence.

C.

Careening, is heaving a Ship down on one Side, while they Trim and Caulk the other.

To Chaſe, is to purſue a Ship; and the Ship ſo purſued is called the Chaſe.

To Cond or *Cun*, is to direct or guide; and to Cun a Ship, is to direct the Perſon at the Helm how to ſteer her. If the Ship go before the Wind, Quartering or Large, then he who Cuns the Ship, uſes theſe Terms to him at Helm, *Steady,— Steady, Starboard, Port* (or *Larboard*) *Helm, a Midſhips. Starboard*, is to put the Helm to the Starboard (or Right) Side, to make the Ship go to the Larboard (or Left,) for the Ship always ſails contrary to the Helm. In keeping the Ship near the Wind, (when cloſe haul'd) theſe Terms are us'd, *Looſ, Looſ, keep your Looſ, Full not off, Veer no more, Keep her to touch the Wind, Have a care of the Lee-latch.* To make her go more Large, or from the Wind, they ſay, *Eaſe the Helm, No near, Bear up*: And when the Ship is *Full* and *By*, as near as ſhe will lie with her Sails full, they ſay, *Thus,— Thus, keep her thus.*

D.

Dead Water; the Eddy-Water at the Stern of the Ship.

To Diſembogue, is to go out of the Mouth of a Strait or Gulph.

The

The Deck is flush fore and aft; that is, laid from Stem to Stern without any Falls or Risings.

E.

END for End; a Term us'd when a Rope runs all out of the Block, so that it is unreev'd; as when a Cable (or Hawser) runs all out at the Hawse, we say, *The Cable or Hawser is run out End for End.*

F.

A *Facke*, is one Circle of any Rope or Cable, quoil'd up round.

To Farthel or Furl a Sail, is to wrap it up close together, and bind it (with flat-plated Strings, call'd Caskets,) fast to the Yard.

To Fish a Mast or Yard, is to fasten a piece of Timber or Plank to the Mast or Yard, to strengthen it; which Plank, *&c.* is called a *Fish.*

Free the Boat or *Ship*, is to Bale, or Pump the Water out.

G.

THE Ship's Gauge, is so many Foot as she sinks in the Water; or to speak more Seaman-like, *so many Foot of Water as she draws.*

Weather Gauge, is when one Ship is to the Windward of another.

A Loom Gale, a little Wind.

The Ship Gripes; that is, turns her Head more to the Wind than she should.

H.

TO *hale*, is the same as to pull.

To over-hale, is when a Rope is not slack enough, to make it more slack.

To Hail a Ship, is to call to to her Company to know whether they are bound, *&c.* and is done after this manner, *Hôa, the Ship!* or only *Hôa*; to which they answer *Hâe.* Also to salute a Ship with Trumpets, or the like, is called *Hailing.*

Fresh the Hawse; a Term used when that part of the Cable that lies in the Hawse is fretted or chafed, and they would have more Cable veer'd out, that another part of it may rest in the Hawse. When Two Cables that come through Two several Hawse-Holes are twisted, the untwisting them, is calledclearing the Hawse.

Thwart the Hawse, and *Rides upon the Hawse*, are Terms used, when a Ship lies Thwart or Cross, or with her Stern just before another Ship's Hawse.

Hawses

Hawſes, are the great Holes under the Head of the Ship, through which the Cables run when ſhe lies at Anchor.

The Ship heels; that is, inclines more to one ſide than the other; as, *She heels to Starboard*, that is, turns up her Larboard ſide, to lie down on her Starboard: If on the other ſide, we ſay, *She heels to Port*.

To Hitch, is to catch hold.

The Hold of a Ship, is that Part betwixt the Lower-Deck and Keel-ſon, where all Goods, Stores and Victuals do lie.

Rammidge the Hold, is uſed for removing or clearing the Goods and Things in the Hold.

To Hoiſe or *Hoiſt*, is to hale or lift up; as, *Hoiſt in the Water*, *Hoiſt up the Yards*, &c.

Hulling; when a Ship is at Sea, and by ſtreſs of Weather, or otherwiſe, takes in all her Sails, ſhe is ſaid to Hull.

L.

THE *Ship Labours*; that is, rowls and tumbles much.

Land-fall, is a Term uſed when we expect to ſee Land; as, *We had a good Land-fall*, that is, made Land, (or ſaw Land) according to our Reckoning.

Land-locked, is when the Land lies round about us, ſo that no Point lies open to the Sea.

Land-to; a Ship is ſaid to lie Land-to, when ſhe is at ſo great a Diſtance as only juſt to diſcern the Land.

Laſh, is to bind faſt.

Launch, to put out; but generally us'd at Sea in a Negative Sence, as when a Yard, *&c.* is hoiſted, or hove by the Capſton high enough, they uſually call aloud, *Launch hôe!* That is hoiſe no more.

To lay the Land, is to loſe ſight of it.

The Lee-Shore, is that Shore againſt which the Wind blows.

Have a care of the Lee-latch; that is, take heed the Ship go not too much to Leeward.

A Ship lies by the Lee; that is, has all her Sails lying flat againſt the Maſts and Shrouds.

M.

MIzen *Sail*, hath ſeveral Words peculiar to it; as, *Set the Mizen*, that is, hale the Sail out, and the Sheet aft. *Change the Mizen*, that is, bring the Yard to the other ſide of the Maſt. *Speck the Mizen*, that is, put the Yard right up, and down by the Maſt. *Spell the Mizen*, that is, let go the Sheet and peek it up.

To Moor a Ship, is to lay out her Anchors, in ſuch a manner, as is moſt convenient for her to ride by ſafely.

N. *Neap-*

N.

Neap-Tides, are the Tides when the Moon is in the Second and laſt Quarter; and they are neither ſo high nor ſo low, nor ſo ſwift as the Spring-Tides.

A Ship is be-neaped, a Term us'd, when the Water does not flow high enough to bring a Ship from off the Ground, or out of a Dock, or over a Bar.

O.

THE Offing, that is, fromward the Shore, or out into the Sea; *as the Ship ſtands for the Offing*, that is, ſails from the Shore into the Sea: Alſo when a Ship keeps the Middle of the Channel, and comes not near the Shore, ſhe is ſaid to *keep in the Offing*.

P.

TO Parcel a Seam, is (after the Seam is caulked, to lay over it a narrow Piece of Canvaſs, and pour thereon hot Pitch and Tar.

To pay a Seam, &c. is to lay hot Pitch and Tar on (after Caulking) without Canvaſs.

To ride a-Peek, is when the Fore and Main-Yard are topt up, or ſo order'd, that they make with the Maſts, as it were the Figure of St. *Andrew's Croſs*.

To Purchaſe, in a Ship, bears the ſame Sence as to draw many times, as, *The Captain purchaſes apace*, that is, draws in the Cable a-pace.

Q.

QUarter-Winds, are when the Wind comes in abaft the Main-Maſt Shrouds, even with the Quarter.

A Quoil, is a Rope or Cable laid up round, one Fack or Circle over another; and the laying of the ſaid Facks one on another is called Quoiling.

R.

A Reach, is the Diſtance between any Two Points of Land, that lie in a Right-Line one from another.

To Reeve, is to put a Rope through a Block; and to pull a Rope out of a Block, is called *unreeving the Rope*.

To Ride; when a Ship's Anchors hold her faſt, ſo that ſhe does not drive with Wind or Tide, ſhe is ſaid to ride at Anchor.

To ride athwart, is to ride with the Ship's ſide to the Tide.

To Ride betwixt Wind and Tide, is when the Wind and Tide are contrary and have equal Strength.

To ride Hawſe-full, is, when in a Rough Sea, the Water breaks into the Hawſe-Holes.

A Road, is any Place near the Land, where Ships may ride at Anchor; and a Ship riding there, is called *a Roader*.

Rowſe-in, (that is, Hale in) proper only to the Cable or Hawſer, and is uſed when the Cable or Hawſer is ſlack, to make it tight or ſtrait.

S.

A *Sail*, beſides its proper Signification, (as belonging to the ſeveral Yards, from which it takes its various Names, as, *Main-Sail*, *&c.*) it ſignifies alſo a Ship, as when we deſcry or ſpy a Ship at Sea, we cry out, *A Sail! A Sail!* Likewiſe if we ſpeak of a Fleet (or a Number of Ships together) we ſay, *The Fleet conſiſted of* 40 or 50 *Sail*, and not of 40 or 50 Ships.

To Sarve a Rope, is to wind ſpun Yarn about it, (with a Mallet for that purpoſe) to keep it from fretting out.

To Seaze, is to make faſt or bind.

The Ship ſeels; that is, when on a ſudden ſhe lies down on her ſide, and tumbles from one ſide to the other.

The Ship ſends; that is, her Head and Stern falls deep in the hollow of the Sea.

To ſettle a Deck, is to lay it lower.

The Ship is ſewed; that is, the Water is gone from her.

The Ship ſhears; that is, goes in and out, and not right forward.

To ſound, is to try with a Hand or Deep-Sea-Line and Lead, how deep the Water is.

The Ship hath ſpent her Maſts; that is, her Maſts have been broke by foul Weather; but if a Ship loſe her Maſts in Fight, we ſay, *Her Maſts were ſhot by the Board.*

The Sail is ſplit; that is, blown to pieces.

The Ship ſpooms; that is, goes right before the Wind without any Sails.

Spring-Tides, are the Tides at New and Full Moon, which Flow higheſt, Ebb loweſt, and Run ſtrongeſt.

The Bow-ſprit ſteeves; that is, ſtands too upright.

Steeving, is likewiſe us'd by Mariners, when they ſtow Cotton or Wool, which being forc'd into ſmall Vacancies in the Hold, with Screws, is called ſteeving of Cotton or Wool.

T.

TACK *the Ship*, or *Tack-about*; that is, bring the Ship's Head about to lie the other Way.

Talle

Take aft the Sheets, a Term us'd for haling aft the Sheets of the Main or Fore-Sail.

A Windward Tide, when the Tide runs againſt the Wind.

A Leeward Tide, when the Wind and Tide go both one Way.

A Tide-gate, where the Tide runs ſtrong.

To Tide it up, is to go with Tide againſt the Wind; and when the Tide is done, and alters, to lie at Anchor till it ſerveth again.

It flows Tide and Half-Tide; that is, it will be High-Water ſooner by Three Hours at the Shore than in the Offing.

To Tow, is to drag a Ship, Boat, or any thing after the Ship.

The Traverſe, is the Ship's Way in 24 Hours, upon the ſhifting of Winds.

V.

TO *Veer*, is to let out; as *Veer more Cable* or *Rope*, *Veer more Sheet*.

W.

THE *Ship is Walt*; that is, wants Ballaſt.

To Weather a Ship, is to go to Windward of her.

To Wind a Ship, is to bring her Head round about.

How Winds (or Capes) the Ship? That is, upon what Point of the Compaſs does ſhe lie with her Head?

To Would, is to bind Ropes about a Maſt or the like, to keep on a Fiſh to ſtrengthen it.

Y.

THE *Ship Yaws*; that is, it goes in and out, and does not ſteer ſteady.

To Work a Ship at Sea, in the proper Sea-Phraſes, and to manage her in Fight.

The Wind is Fair.

THE Wind is fair, tho' but a little; it comes well, as if it would ſtand; therefore up 2 or 3 Hands, and looſe the Fore-top-ſail in the Top: Hoiſt the Colours, Unmoor the Ship; and heave up the Anchors. Haul home the Fore and Main-top-ſail-ſheets; looſe the Fore-ſail and Mizen in the Brails.— Come my Hearts, heave up the Anchor, (that we may have a good Prize:) Heave away cheerly: Come, who ſays Amen? One and all. O brave Hearts, the Anchor is a-Peek: Hoiſt the Fore and Main-top-ſails; the Anchor is a-Weigh: Let fall the Fore-ſail, and Haul the Sheets aft:

aft: Up, and looſe the Main-ſail, and ſet him; Cat and Fiſh the Anchor; mind your Steerage, Right the Helm; Steddy, ſteddy.— The Ship is wore; looſe Sprit-ſail, and Sprit-ſail-top-ſail. A brave Gale; bring the Fore-tack to the Cat-Head, with a Paſerebo; and trim our Sails quartering: Looſe Top gallant-ſails, and hoiſe up our ſmall Sails; heave out the Mizen-top-ſail, and ſet him. Now we are clear of the Land, and the Wind like to ſtand: Hoiſe in the Boats before it is too much Sea; haul up the Main-ſail and Fore-ſail, and haul down your ſmall Sails.— A-Lee the Helm handſomly, and bring the Ship too eaſily, that ſhe may not ſtay: Brace the Fore-top-ſail to the Maſt: Paſs Ropes for the Boat's on the Lee-ſide; and be ready to clap on your Tackles, and Hoiſt them in; ſtow them faſt.— Put the Helm a-Weather, fill the Fore-top-ſail. Get the Fore-tack to the Cat-head again; and haul aft the Fore-ſheet, and trim the Sails quartering as before: Let fall the Main-ſail, and haul aft the Main-ſheets.— Hoiſt up the Top-gallant-ſails, ſet the Sprit-ſail-ſprit-ſail, Top-ſail, and Main-mizen, (Fortop-maſt-main) Top-maſt-ſtay-ſails, and the other ſmall Sails: Come, rig out the Steering-ſail-booms, and get up our Steering ſails; that we may make the beſt of our Way to our Cape, (or Port.) Clear your Ropes; and now we have Sea-Room enough, ſtow your Anchors, and unbend the Cables; get the Bucklers on the Hawſe-holes; Cork in the Lower-Deck-ports.—— We lay the Land a-pace, and make great Way thro' the Water. How bears the Point of Land (our Farewel-Cape?) N.b.W. about 7 Leagues diſtant; aft heave the Log: How many Knots does ſhe run? 9 Knots and ½; ſet it down on the Log-Board, with the Courſe ſteered; as alſo, the Bearings and Diſtance ftom Land: Mind the Compaſs and ſteerage; How wind ye? S.W.b.W. — Keep her away on her Courſe, W.S.W. ſo Steddy,-- ſteddy; ſettle the Watch and mind the Sails, *&c.*

Thus you have a gallant Ship, under all her Sails and Canvaſs, in her ſwifteſt way of ſailing upon the Sea. Now let us have her right before the Wind.

Right afore the Wind, and a freſh Gale.

THE Wind is veered right aft, take in your Fore and Fore-top-ſail-ſteering-ſails, and Fore and Main-top-ſail-ſtay-ſails; for they are becalm'd by the After-ſails, and will only beat out: The Wind blows a freſh Gale; round aft the Fore and Main-ſheets, ſquare the Yards, take in the Steering-ſails, and Top-gallant-ſails, in Sprit-ſail-ſprit-ſail, and Mi-

Mizen-top-ſails. Let go the Sheets, clew them up, and hand them.

Thus you have all the ſmall Sails in and furled, when it blows too hard to bear them.

The Wind veereth forward and ſcanteth.

THE Wind ſcanteth, veer out ſome of your Fore and Main-ſheets, and Sprit-ſail-ſheets, and let go your Weather-braces; Top the Sprit-ſail Yard.— The Wind ſtill veereth forward; get aboard the Fore and Main-tacks; caſt off your Weather-ſheets and Braces.—— The Sails are in the Wind; haul aft the Fore and Main-ſheets: The Wind is Sharp, haul forward the Main Bow-line and Fore Bow-line; and haul up the Fore-top-ſail and Main-top-ſail-bow-lines, and ſet in the Lee-braces: Trim, ſharp, and keep her full and by, as near as ſhe will lie.

Thus have you all the Sails trim'd ſharp, and the Ship by (or upon) a Wind.

The Wind blows freſh or friſking.

THE Wind begins to blow freſh, and it looks dirty to Windward; Come reef the Top-ſails cloſe, taking in all the Reefs; ſlide down the ſhifting Back-ſtays, One third of the Maſts lower. Hoiſt the Top-ſails, ſet in the Lee-braces; the Wind blows harder, ſettle the Fore and Main-top-ſails Two thirds of the Maſt down.—— It is more Wind, ſtand by the Lee-ſheets, and Top-ſails-hallyards; haul down both Top-ſails, cloſe; ſtand by, take in the Fore top-ſail: Let go the Fore-top-bow-line and Lee-braces; let go the Lee-ſheet, ſet in your Weather-brace; ſpill the Sail, haul up the Top-ſail-clew-lines; ſquare the Yard, haul up the Bunt-lines and Leech-lines; and bear a Hand, and furl the Sail.——Come, ſtand by again to hand the Main-top-ſail.——Come, take in the Main-top-ſail; let go the Main-top-bow-line, and Lee-brace; let go the the Lee-ſheet, ſet in your Weather-brace; ſpill the Sail, haul home the Top-ſail-clew-line; and haul up the Bunt-lines and Leech-lines, and bear a Hand; furl the Sail.

Now the Top-ſails are furl'd, and you have the Ship in all her Low-ſails or Courſes.

It bloweth a Storm.

IT is like to over-blow, ſtand by to haul up the Fore-ſail; caſt

caſt off the Top-ſail-ſheets, Clew-garnets, Leech-lines, Bunt-lines; ſtand by the Sheet and Brace; haul up the Fore-ſail, let go the Fore-ſheet, raiſe the Fore-tack; haul up the Clew-garnets, Bunt-lines and Leech-lines; lower the Yard, and furl the Sail.——Here is like to be much Wind; ſee that your Main, (Jeers) and Hailyards be clear; and all the reſt of your Geer clear and caſt off. Is it all clear? Yea, yea: Come, lower the Main-yard; haul down upon your down-haul: Now the Yard is down, haul up the Clew-garnets, Lifts, Leech-lines, Bunt-lines, and furl the Sail faſt; and faſten the Yards, that they may not traverſe and gall.

Thus have you have the Ship a-try, under a Mizen.

A very hollow-grown Sea.

WE make Foul Weather; Gunner, look that the Guns be well laſht, and their Trucks quoin'd.—— Come aft, haul the Mizen up. The Ship lies very broad off in the Trough of the Sea; ſee the Hatches well ſecur'd, and the Tarpaulins nail'd over them.—— It is better Spooning before the Sea, than trying or hulling: Come, my Hearts, Reef the Fore-ſail and ſet him; haul aft the Fore-ſheet, put the Helm hard a-Weather; mind at Helm what is ſaid to you: The Ship wares bravely, ſteddy, ſteddy; ſhe is before it.——The Fore-ſail is ſplit to pieces; forward my Hearts: Haul down the Yard, and get the Sail into the Ship, and unbend all things clear of it.—— Starboard, hard up, right your Helm, Port, Port, Port, hard; get able Men to the Helm.——A very fierce Storm; the Sea breaks, ſtrange and dangerous.—— The Ship has broach'd too, and the Sea hath fill'd us full and full upon Deck; but there is but little gone down the Hold. Come, ſound the Well, try the Pump; ſpell and ſpell: She makes but little Water. Come, my Hearts, let's try to Ware the Ship again; our Canvaſs will not hold the Wind,—— Well then, get up as many Men as can well ſtand in the Weather Fore-ſhrouds, hard a-Weather your Helm; hard up.——The Ship wares round, ſo right the Helm; ſteady, ſteady, mind the Helm carefully: Shall we get down our Top-maſts? No, let all ſtand; ſhe ſcuds before the Sea very well: The Top-maſts being aloft, the Ship is the wholſomeſt, and makes better way through the Sea, ſeeing we have Sea-room.

Thus you ſee the Ship handled in fair Weather and foul, by and large: Now let us ſee how we can turn to Windward.

The

The Storm is over, let us turn to Windward.

THE Storm is over, ſet Fore-ſail and Main-ſail, bring the Ship too; ſet the Mizen, the Main-top-ſail, the Fore-top-ſail, and Mizen-top-ſail; our Courſe is W.S.W. the Wind is at S. get the Larboard Tacks aboard; caſt off the Weather-braces and Lifts; ſet in the Lee-braces, and hale aft the Sheets; haul forward the Bow-lines, haul the Mizen-tack over to Windward; keep her full and by as near as ſhe will lie: How Wind ye? W. a quade Wind: No near, hard, no near; the Wind yeereth to the Weſtward ſtill: How Wind you? N.N.E. The Wind will be Northerly, make ready to go about; we ſhall lie our Courſe the other way: No near, give the Ship way, that ſhe may ſtay; Ready, ready, a-Lee the Helm; let go the Fore-top-bow-line, veer out the Fore-ſheet handſomly; caſt off the Lee-braces, of your Fore-ſail and Fore-top-ſail; brace in upon your Weather-braces: Tend the Ship brace a-back; the Fore ſails is a-back-ſtays; (the Wind is a-head;) haul Main-ſail, haul; let riſe the Main-tack; caſt off the Star-board-braces; let go the Main-bow-line, and Main-top bow-line; brace about the Yard, haul forward the (Starboard) Main, and Main-top-bow-line, Mizen-top-ſail-bow-line; brace the Croſs-jack-yard, ſet in the Lee-braces of the Main-yard-main-top-ſail, and Mizen-top-ſail-yard; get the Main-tack cloſe down in the Cheſs-tree; haul the Main-ſheet cloſe aft; haul off all, haul.—Get aboard the Fore-tack, let go the Fore-bow-line, Fore-tack; let go the Fore-bow-line, Fore-top-bow-line; ſet in the Lee-braces of the Fore-yard, and Fore-top-ſail-yard; haul aft the Fore-ſheet; haul tight the Main-bow-line, and Main-top-bow-line; ſhift the Mizen-tack, haul tight the Fore-bow-line, Fore-top-bow-line; and ſet in the Lee-braces, fore and aft; keep her as near as ſhe will lie; ſo, thus, thus, come no nearer.—Fall not off, Loof, Loof; How Wind you? W.N.W. Thus ware, no more, keep her full; How wind you? N.W. The Wind is at N.N.E. keep her away her Courſe, W.S.W. caſt off the Lee-braces and Weather-bow-lines, and ſet in your Weather-braces; veer out the Main-ſheet and Fore-ſheet; looſe the Sprit-ſail and Sprit-ſail-top-ſail, and Top-gallant-ſails, and hoiſe them up; ſet the Stay-ſails, and Small-ſails; the Wind veers aft ſtill; the Wind is quartering, haul aft the Starboard Fore ſheet; let riſe the Fore tack, bring it down to the Cat head with a Paſs.a-ree; ſteddy in your Weather-brace; the Wind ſtands a brave Gale, and we make good way through the Water.

Thus

Thus you have the Ship as at the firſt ſteering, under all her Canvaſs, Quarter-Wind: She hath been wrought in all manner of Weather, and all ſorts of Winds: Therefore ſhall draw to a Concluſion of this Section, with a Man of War in Chaſe, and taking of her Prize.

The cruizing Man of War in her Station.

NOW we are in our Station, and a good Latitude; hand your Top-ſails, and furl your Fore-ſail and Main ſail; and brail up the Mizen, and let her lie a-Hull, until Fortune appear in our Horizon: Up aloft, a Man to the Main top-maſt head, and look well out, if you can ſee any Ships that have been nipt with the laſt Northerly Winds.——A Sail, a Sail: Where? Fair by us. How ſtands ſhe? To the Eaſtward; and is about Two Points upon our Lee-bow, and hath her Larboard-tacks aboard: O, then ſhe lies cloſe by a Wind.——We ſee her upon the Decks plainly: A Couple of good Men to the Helm; up and looſe the Fore-ſail, Main-ſail, and Mizen; get the Larboard-tacks aboard; heave out the Fore-top-ſail, Main-top-ſail, and Mizen top-ſail; looſe the Sprit-ſail, keep her as near as ſhe will lie; haul aft the Sheets, and haul up your Bow-lines tight. Do you ſee your Chaſe? Yea, Yea: How wind you? E.N.E. Then the Wind is at N. hoiſe up your Top-ſails, as high as you can; come, ſet the Sprit-ſails, Sprit-ſail-top ſail, Flying Jibb, Top-gallant-ſails, Main and Mizen ſtay-ſails, Main and Fore-top ſail ſtay-ſails, and the Top-gallant-ſtay-ſails.—— It blows a brave Chaſing Gale; the Ship makes brave way through the Water; we raiſe her apace; if ſhe keep her Courſe we ſhall be up with her in 3 or 4 Glaſſes; no near, keep the Chaſe open with the Lee-latch of the Fore-ſail; ſo keep her thus.——Come aft all Hands, the Ship will ſteer the better, when you ſit all quiet by her Small-ſail, for ſhe is too much by the Head: The Chaſe is a luſty brave Ship; ſo much the better, ſhe hath the more Goods in her Hold: the Ship hath a great many Guns; no matter, we can match her.——No near, the Chaſe is about; come fetch her Wake, and we will be about after her; we ſail far better than ſhe.——We have her wake, a Lee the Helm; eaſe off the Fore-ſheet, handſomly; every Man ſtand handſomly to his Buſineſs, and mind the Bow-lines and Braces, Tacks and Sheets.—— The Wind's a Head; haul Main-ſail, haul; let go Main bow-line, Top bow-line, Top-gallant bow-line; get aboard the Main tack; haul aft the Main ſheet; brace the Main-

Main-yard, Main-top-ſail, and Main-top-gallant-yard, Croſs-jack, and Mizen-top-ſail-yard; ſhift the Mizen-tack.——Haul off all, haul; ſhift the Helm, bring her too; haul the Fore-ſheet cloſe aft, ſet in the Lee-Braces; haul tight the Bow-lines. The Chaſe keeps cloſe upon a Wind; keep her open under our Lee.——Gunner, ſee that you have all Things in readineſs, and that our Guns be clear; let nothing peſter our Decks.——Get up all the Hammocks, and ſtow them in the Nettings of the Quarter-Deck, Fore-Caſtle, and on the Gun-wall in the Waſte; down with all the Bulk-Heads, *&c.* that may hinder, or hurt us with Splinters.——Gunner, is all our Military Gear ready? Is there ſtore of Cartridges of each ſort, ready fill'd; all manner of Shot in the Garlands between the Guns, and at the Main-maſt? Are there Rammers, Sponges, Ladles, Priming-Irons, Horns, Linſtocks, Wads, Swabs, and Water in the Tubs, at their ſeveral Quarters, ſufficient for them? Be ſure that none of our Guns be cloy'd; and when we are in Fight, be ſure to load our Guns with Croſs-bar and Langrel; always obſerving to give Fire when the Word is given.——See that the Blunderbuſſes, Muſketoons, Firelocks, Piſtols, Swords, Cutlaſhes, Pole Axes, Half-Pikes and Javelins be in readineſs; and all our Cartouch-Boxes and Bandaleers, fill'd and furniſh'd with Powder and Shot; ſee that our Patereroes in the Tops, with the Murtherers and Stock Fowlers, have their Chambers fill'd with good Powder, and Bags of Small ſhot to load them; that if we ſhould be laid aboard, we might clear our Decks.——Lieutenants, call over the Quarter Liſt, and ſee every Man and Boy, at their Gun's Small-Arms; and in the Tops at their ſeveral Quarters.——Obſerve when we are near the Chaſe, in Fight, to load our Guns with Double-head round and Partridge-Shot, and to Fire our ſmall Arms. The Chaſe pays away more room.——Hard a Weather, veer out ſome of the Main-ſheet, and Fore-ſheet, caſt off the Larboard braces; ſteddy, ſteddy, Right the Helm; keep her thus; well ſteer'd, The Chaſe goes away room, her Sheets are both aft; ſhe is right before the Wind; Starboard hard; let riſe the Main-tack, let riſe the Fore-tack; haul aft the Fore-ſheet.——We have a Stern Chaſe, but we ſhall be up with her preſently, for we fetch upon her Hand-going. Hoiſt our Colours, ſpread the Waſt Cloths and Top Armours. The Chaſe hauls up her Main-ſail and furls it; ſhe puts abroad her Waſte-Cloths; ſhe will Fight us: Come, my Hearts, up and furl our Main-ſail, ſling our Main-yard with the Top-Chains, ſling our Fore-yard.—— She will fight us before the Wind; I ſee ſhe is full of Men; it is a Hot

Ship, but Deep and Foul; ſhe is a 60 Gun Ship, and full of Men; (but we ſhall match her, altho' we have but 50 Guns.) Come, cheerly my brave Hearts, it is a Prize worth fighting for: The Chaſe takes in her Small-ſails; up and take in our Top-gallant-ſails, Sprit-ſail, and Sprit-ſail-top-ſail; get the Sprit-ſail-yard along Ship under the Bow-ſprit.——She puts abroad her Colours, they are White; they are *French* Colours, no Force; Boys, ours are St. *George*'s.——Call all Hands aloft. Come up aloft all Hands: They are all up, Captain.

——*The Captain's Speech.*

GENTLEMEN, We are here employ'd and maintain'd by his Majeſty King *George*, and our Country; to do our Endeavours to keep the Sea from Piracy and Robbers, and his Majeſty's Enemies; and it is our Fortune to meet this Ship at this time: Therefore, I deſire you in his Majeſty's Name, and for the ſake of our Country, and the Honour of our *Engliſh* Nation, and our ſelves, that every Man behave himſelf Couragious, like *Engliſhmen*; and not have the leaſt ſhew of a Coward. But obſerve the Words of Command, and do his utmoſt Endeavour. Into God's Hand we commit our Cauſe, and our ſelves; ſo every Man to his Quarter, and ſhew his Courage, and God be with us, and grant us the Victory.

She ſettles her Top-ſails, we are within ſhot; let all our Guns be looſe in the Tackles, and the Ports all knock'd open, that we may be ready to run out our Guns when the Word is given; up noiſe of Trumpets and Hail our Prize; ſhe anſwereth again with her Trumpets: Hold faſt Gunner, do not Fire till we hail them with our ſpeaking Trumpet; Port edge towards him; ſo, now we are fairly along ſide of him, and within Musket-ſhot: Come, my brave Men, run out your Guns, and give him a Broadſide, a Volley of ſmall Arms, and a Huzza.——Well done, my Hearts.—He returns our Compliment, by firing his Broadſide upon us.——What chear, my Hearts, is all well betwixt Decks? Yea, yea, only he has rak'd us through and through; no Force, it is his Turn next; but give not Fire again, till we are within Piſtol-ſhot: Port edge towards him, he plies his Small-ſhot. Come, Boys, Load and fire our ſmall Arms briskly at him: Hold faſt Gunner; Port, Right your Helm, we will run up his ſide; Starboard a little, Fire a Broadſide, Gunner.——That was well done; this Broadſide hath made their Decks thin of Men, but his Small-ſhot at firſt did gaul us.——Clap in ſome Caſe or Partridge-ſhot in the Guns.——You are now a Loading: Brace too the Fore-top-ſail, that we may not

ſhoot

ſhoot a-Head of him; he lies broad off to the Southward, to bring his other Broadſide to bear upon us: Starboard, hard; get aboard the Larboard Fore-tack, trim your Top-ſails; run out your Larboard Guns: He fires his Starboard Broadſide upon us; he pours in his Small-ſhot: Starboard, give not Fire until he fall off, that the Prize may receive our full Broadſide; ſteddy, Port a little: Fire a Broad-ſide. His Fore-maſt is by the Board; this laſt Broadſide hath done great Execution; Huzza, cheerly my Mates, the Day will be ours, he is ſhot a-Head; he bears up before the Wind, to ſtop his Leaks: Keep her thus, well ſteer'd; Port, Port hard; bear up before the Wind, that we may give him our Starboard Broadſide: Gunner, ſee that the Guns be loaded with Double-head-round and Caſe-ſhot: Yea, yea. Port, make ready to board him, have your Laſhers and Graplings ready, and able Men with them: Edge towards him; when you give Fire, bring your Guns to bear amongſt his Men, with the Caſe-ſhot; well ſteer'd, we are cloſe on Board.; give Fire again: Starboard, well done my Hearts; they lie Heads and Points aboard the Prize; come, board him bravely: Enter, enter, Are you laſh'd faſt? Yea, yea, we will have him before we go here-hence.——Cut up the Decks; ply your Hand-Granadoes.——He cries out Quarter: Quarter for our Lives, and we will yield up Ship and Goods.—Good Quarter is granted, provided you will lay down all your Arms, open the Hatches, haul down all your Sails, and furl them; looſe the Latchings, we will ſheer off our Ship, and hoiſt out our Boats: If you offer to make any Sail, or Fire again, expect no Quarter for your Lives—— Go aboard him with our Boats; and ſend aboard the Captain, Lieutenant, Maſter and Mates, with as many more as our Boats will carry.

So will we leave the Man of War to his Prize and Plunder, and to ſecure his Priſoners; and ſhall conclude this Section with Ovid, *when he ſail'd in the* Ionian *Streights.*

NOTHING but Waves we view, in Sea where Ships do float;
And Dangers lie, huge Whales, and all Fiſh play:
Above our Heads, Heaven's Star-embroider'd Coat;
Whoſe Vault contains Two Eyes for Night and Day.
Far from the Main, or any Marine Coaſt,
'Twixt *Borean* Blaſts, and Billows we are toſs'd.
(If OVID, in that Streight of *Ionian* Deep,
Was toſs'd ſo hard; much more are we, on Seas
Of larger Bounds; where Staff and Compaſs keep
Their ſtrict Obſervance: Yet in this Uneaſe

Of Tacking-Boards, we ſo the Way make ſhort,
That ſtill our Courſe draws nearer to our Port.)
Between the Sea and Silver-ſpangled Sky,
We rowling climb, then hurling fall beneath:
Our Way is Serpent-like, in Meads which lie,
That bow like Graſs, but never make a Path;
But fitter like Young Maids and Youths together;
Run here and there, all where, and none knows whether.
Our Way we know, and yet unknown to other;
And whilſt miſ-known to us, before we dive,
The Hand and Compaſs, that governs the Rudder,
Do often err; altho' the Pilots ſtrive
With Chart and Compaſs: Yet our Reckonings fall
Too narrow, ſhort, too high, too wide, too ſmall.
To diſcon this Remark, when we ſet Land,
Some this, ſome that do gueſs; this Hill that Cape.
For ſome Hours our Skill in ſuſpence ſtand;
Terming this Shore, that Head-Land points the Map:
Which when miſtook, this forg'd Excuſe goes clear,
O *ſuch and ſuch a Land it firſt did 'pear.*
In all which Strife, ſtreſs'd Sailors have the Pain;
By drudging, pulling, haling, ſtanding to it:
In Cold and Rain, both dry and wet, they ſtrain
Themſelves, and toyl; none elſe but they muſt do it.
Both *Prow* and *Poop* do anſwer to the *Helm*:
The *Steerſman* ſings; no Grief his Joy can whelm.
By Night our Watch we ſet, by Day our Sight;
And make more ſail, if Pirates do appear;
We reſt reſolv'd, 'Tis Force make Cowards fight;
Tho' none more dare, than they that have moſt Fear.
It's *Courage* makes us Raſh, and *Wiſdom* Cold:
Yet Wiſe Men, Stout, and Strong, grow Lion-bold.
The Wiſe Man knows his Wiſdom how to uſe;
The Artificer, what Art 'tis beſt to chuſe.
'Tis a True Saying, and approved long,
The Wiſe Man is more Worthy than the Strong:
The Field he Tills, the City he can guide;
And for the Ships in *Tempeſts* will provide.

For defenſive Sea-fighting, ſee Park's *Art of Sea-fighting in Merchant Ships*, &c.

Of

Of the Sea or Ocean.

THE continual Motion and Agitation, Flux and Reflux of the Sea, is of great Uſe in Navigation; and the Seas thereby purge themſelves: By which they are kept from Putrefaction; like a Fountain it cleanſes it ſelf. Iſa. 57. 20. *It cannot reſt*, but *caſts up Mire and Dirt*; whereas Lakes and Ponds, whoſe Waters are ſtanding and dead, corrupt and ſtink. And it is obſerv'd by Seamen, that in the Southern Parts of the World, where the Sea is more calm and ſettled, it is more corrupt and unfit for Uſe. So is the Sea of *Sodom* called *The Dead Sea*: In which, 'tis reported, that the Birds flying over it, drop down Dead.

The Seas within their Bounds the Lord contains;
He alſo Men and Devils holds in Chains.

It is a wonderful Work of the All-wiſe Creator, to limit and bound ſuch a vaſt and furious Creature as the Sea: Which, according to the Judgment of the Learned, is in many Places higher than the Earth; as in *Holland*, &c. And that it hath a Propenſion to over-flow it, is evident, both from its Nature and Motion: Were it not that the Omnipotent and Omniſcient GOD, has laid his Law upon it. And this is a Work where the Lord glories, and will be admir'd: Pſal. 104. 9. *Thou haſt ſet a bound that they may not paſs over, that they turn not again to cover the Earth*; which it is clear they would do, were they not thus limited. So *Job* 38. 8, 10, 11. *Who ſhut up the Sea with Doors, when it brake forth as if it had iſſued of the Womb? I brake up for it my decreed place, and ſet Bars and Doors; and ſaid, Hitherto ſhalt thou come, but no further; and here ſhall thy proud Waves be ſtaid.*

In the vaſt Ocean Seamen may deſcry
God's boundleſs Mercy and Eternity.

The Ocean is of a vaſt Extent and Depth, though ſuppoſedly meaſurable; yet not to be ſounded by Man in many Places. It compaſſeth about the whole Earth, which in the Accompt of Geographers, is 26293¼ Miles, and its Diameter 8369 *Engliſh* Miles: The Surface of the Earth contains

2200-

220048209½ of Square *Engliſh* Miles; containing about 70 Millions of Millions of Acres: And its Solidity is 30693016053 5½ of Cubick *Engliſh* Miles, which is the Solid Content of the Terraqueous Globe). Yet the Ocean invirons it on every Side; (*Pſal.* 104. 25. *Job* 11. 9.) ſuitable to which is that of the Poet:

Tum freta diffudit, rapidiſve tumeſcere ventis
Juſſit & ambitæ circumdare littora terræ. Ovid.

He ſpread the Seas, which then he did command
To ſwell with Winds, and compaſs round the Land.

And for its Depth, who can diſcover it? The Sea, in Scripture is called *the Deep*, Job 38.30. *The great Deep*, Gen. 7.11. The *gathering together of the Waters into one Place*, Gen. 1.9. If the greateſt Mountains were caſt into it, it would appear no more than the Head of a ſmall Pin in a Tun of Water.

The Waters of the Sea in themſelves, are Brackiſh, Salt, and Unpleaſant: Yet, being exhal'd by the Sun and condens'd into Clouds, they fall down in pleaſant Freſh Showers: Or if drained through the Earth, their Property is thereby alter'd; and that which was ſo ſalt in the Sea, becomes exceeding ſweet and pleaſant in the Spring. This we find by conſtant Experience, the ſweeteſt Chryſtal Spring came from the Sea, *Eccleſ.* 1.7.

Of the Nature and Qualities of the principal Winds.

"THE Wind, ſaith *Ariſtotle*, is an Exhalation Hot and "Dry, engendred in the Bowels of the Earth; and "being gotten out, is carried ſidelong upon the Face of the "Earth." The *North-Wind*, called *Septentrio*, *Aquilo*, or *Apartias*, is extreamly Cold and Dry, prohibiting Rain: It preſerveth Health by cleanſing the Air of all Peſtiferous Infections; but it cauſeth Dry Colds, and hurteth the Fruits and Flowers of the Earth.

The N.E.b.N. called *Aquilo* or *Boreas*, is alſo Cold and Dry, without Rain: It hurteth the Flowers and Fruits of the Earth, and eſpecially the Vines when they bud.

The N.E.b.E. called *Helleſpontus* or *Cæcias*, is Hot, drying up all Things.

The

The *East-Wind*, called *Eurus*, *Subſolanus*, or *Apeliotis*; is Hot and Dry, Temperate, Sweet, Pure, Subtle and Healthful; and eſpecially in the Morning when the Sun riſeth, by whom it is made more Pure and Subtile, cauſing no Infection to Man's Body.

The E.S.E. called *Eurus* or *Vulturnus*, is alſo Hot and Dry: It bloweth lowd, and therefore is call'd *Lucretius*, *Altitonans*, *Vulturnus*.

The S.E.b.S. called *Euroaſter*, or *Euronotus*, is Hot and Moiſt, and breedeth Clouds and Sickneſs.

The *South-Wind* called *Auſter* or *Notus*, is Hot and Moiſt; breeding thick Clouds, great Rains, and peſtiferous Air.

The S.W.b.S. called *Auſtro-Africus* or *Libonotus*, is temperately Hot; and yet, breedeth Rain and Sickneſs as ſome write.

The S.W.b.W. named *Africus* or *Libs*, is Cold and Moiſt, cauſing Rain.

The *Weſt-Wind*, called *Favonius* or *Zephyrus*, is temperately Hot and Moiſt, and wholeſome in the Evening: It diſſolveth Froſt, Ice, and Snow, and maketh Flowers and Herbs to ſpring; and ſome write, that it cauſeth Thunder.

The *W.N.W.* called *Corus* or *Syrus*, is Cold and Moiſt, without any great rigour.

The *N.W.b.N.* called *Syrus* or *Trachias*, is Cold and Dry, of Earthly Nature, breeding Snow and Winds, and oft-times Storms and Tempeſts. Thus,

Through many Fears and Dangers Seamen run,
But all's forgotten when they do return.

Of which we have an Elegant and Lively Deſcription, *Pſal.* 107. 25,26,27. *He commandeth, and raiſeth the ſtormy Winds, which lifteth up the Waves of the Sea: They mount up to Heaven; they go down again to the Depths: Their Soul is melted becauſe of the Trouble; they reel to and fro, they ſtagger like a drunken Man; they are at their Wits end:* Or, as it is in the *Hebrew*, *all Wiſdom is ſwallowed up.* Suitable to which, is that of the Poet:

Rector in incerto eſt, nec quid fugiatve petatve,
Invenit ambiguis ars ſtupet ipſe malis. Ovid.

The Pilot knows not what to chuſe or flee,
Art ſtands amaz'd in Ambiguity.

Theſe dreadful Storms do at once diſcover to us the mighty Power of God in raiſing them; and his abundant Goodneſs

neſs in preſerving poor Creatures in them. *Firſt*, The Power of God is graciouſly manifeſted in raiſing them: The Wind is one of the Lord's Wonders, *Pſal.* 107. 24, 25. *He commandeth and raiſeth the ſtormy Wind.* Yea, *Verſe* 18. God appropriates it as a peculiar Work of his; *He cauſeth (his Wind to blow.)* Hence he is ſaid in Scripture to bring them forth of his Treaſury: *Pſal.* 137. 7. *There they are locked up and reſerved*; not a Guſt can break forth, till he command and call for it to go and execute his Pleaſure: Yea, he is ſaid to hold them *in his Fiſt*, *Prov.* 30. 4. What is more uncapable of holding than the Wind? Yet God holds it: Altho' it be a ſtrong and terrible Creature, he controuls and rules it. Yea the Scripture ſets forth God as *riding upon the Wings of the Wind*, Pſal. 18. 10. It is a borrowed Speech from the manner of Men, when they would ſhew their Pomp and Greatneſs, *Ride upon ſome ſtately Horſe or Chariot*; ſo the Lord, to manifeſt the Greatneſs of his Power, rides upon the Wings of the Wind, and will be admir'd in ſo terrible a Creature. And no leſs his glorious Power appears in remanding them, than in making them.

The Heathens aſcribe this Power to their God *Æolus*; but we know this is the Royalty and ſole Prerogative of the true God, who made Heaven and Earth: It is he that makes the Storm a Calm, *Pſal.* 107. 29. and it is he that ſhifts and changes it from Point to Point of the Compaſs, as he pleaſeth; for he hath appointed them in their Circuits, *Eccleſ.* 1. 6. *The Wind goeth toward the South, and turneth about unto the North; it whirleth about continually, and returneth again according to his Circuits.* And as we ſhould adore his Goodneſs in preſerving Seamen (in a poor weak Veſſel) in the height of all their Fury and Violence: Therefore I ſhall conclude this Diſcourſe, with a Poem out of that excellent Book of Mr. *John Flavel's*, *Navigation ſpiritualiz'd*, P. 30. viz.

A Deſcription of a Ship in a Storm and Diſtreſs.

THE Ship that now ſails trim before the Wind,
E're the deſir'd Port it gains, may find
A tedious Paſſage: Gentle Gales a while
Do fill its Sails; the flattering Seas do ſmile:
The Face of Heaven is bright; on every ſide
The wanton *Porpice* tumbles on the Tide.
Into their Cabbins now the Seamen go,
And then turn out again, with *What Chear ho?*
All on a ſudden, dark'ned are the Skies,
The Lamp of Heaven obſcur'd, the Winds do riſe;

The

Waves ſwell like Mountains: Now their Courage flags,
The Maſts are ſprung, the Sails are torn to Rags.
The Veſſel works for Life; anon, one cries,
The Main-maſt's gone by th' Board: Another plies
The Pump, until a third do ſtrike them blank,
With, *Sirs, prepare for Death w'have ſprung a Plank.*
Now to their Knees they go, and on this wiſe,
They beg for Mercy with their loudeſt Cries:
Lord, ſave us but this once, and thou ſhalt ſee
What Perſons for the future we will be:
Our former Time's miſ-ſpent; but with a Vow
We will engage, if thou wilt ſave us now,
To mend what is amiſs. The gracious Lord,
Inclin'd to Pity, takes them at their Word:
The Winds into their Treaſure he doth call;
Rebukes the ſtormy Sea, and brings them all
To their deſired Haven: Once a-ſhore,
And then their Vows are ne'er remember'd more.

Of the various Colours of the Sea.

THE Variety of Colours of the Sea-Water, at ſeveral Times chiefly depends upon the Wind and Weather, Deepneſs or Shoalneſs of the Sea, and the Reflection of the Light upon it. Its uſual and moſt natural Colour, is a deep Green: But in Cloudy and Rainy Weather, the Surface of the Water appears Blackiſh; and ſometimes of a deep Blue, according to the Colour of the Sky, and the great Depth of the Water. On Sands (or Shoals) upon the Tide of Flood, the Water is generally White; the Waves, by reaſon of the Shallows, meeting with Oppoſition, and breaking into Foam, till the Flood is well advanced. Sometimes the Water is of a perfect Azure Colour, the Sun ſhining bright upon it. Sometimes the upper Part of the Waves appears Purpliſh, ſometimes Reddiſh: Though in Shallows perchance it may receive this latter Tincture alſo from the Sands which lie under it; and ſo 'tis thought of the Red-Sea.

I have obſerv'd, when the Ship has been under ſail, and the Wind has freſhned, the Waves at the Head and Sides of the Ship, to appear with a Pale kind of Brightneſs: So have I ſeen at Night, by the Sides and Bow of the Ship, the Sea as it were a ſparkling Flame: The ſame alſo is obſervable in a Boat's Rowing in the Night, by the Oars falling

roughly into the Water, ſeems as a continued Flame; which I aſcribe rather to the Saline Particles of the Sea-Water, which were then put into a violent Agitation, than to the Spawn of Fiſh, as ſome of our Seamen imagine.

Natural Prognoſticks of the Weather, deduced from Philoſophical Aphoriſms, *and frequent Experience of Judicious Perſons.*

I. By the SUN.

IF the Sun look Pale, look for Rain; if Fair and Bright Fair Weather; if Red, Wind.

If the Sun appear in the Eaſt, greater than it uſually doth, it is a Sign of Rain.

The Sun riſing Bright and Clear, ſignifieth a pleaſant Day: If he riſe Fiery Red, or ſhews Broad, as through a Miſt, or has a Circle about him, expect Rain.

If the Sun drive the Clouds before him into the Weſt, it ſignifieth Fair Weather: If at his riſing there appear a Circle about him, and vaniſheth away, equally, it betokeneth Fair Weather.

If at the Riſing of the Sun, his Beams ſeem Red or Long, or encompaſſed with Red Clouds, it ſignifieth great Winds: If at his Riſing there appear a thick Miſt, or if it raineth in the Evening, it threatneth very foul Weather to follow: Alſo if the Sun-Beams be ſpotted either Green, Pale, or Black, or gathered to a Cloud it ſignifieth Rain.

If the Circle or Circles about the Sun be clear, and of no Continuance, look for Fair Weather.

If there be many Circles, it ſignifieth Winds; the Redder they are, the more vehement Winds. If the Circles are here and there broken, and are Thick and Black, look for cold Wind or Snow: Or if the Sun ſettles behind a great Black Cloud, Rain follows.

If a Black Cloud appear, and about Sun-ſetting, it will Rain that Night or the Morning following. Or if He ſetteth Red, or Clear without a Cloud, it ſignifieth Fair Weather. If at his ſetting he be of divers Colours, or Clouds like Water, it threatens Rain: Or if it raineth in the Evening, Foul Weather will follow. If there appear Fiery Spots in the Sun at his Setting, much Wind will enſue.

II. By the MOON.

IF the Moon look Pale, look for Rain; if Fair and Bright, Fair Weather; if Red or Bluſhing, Storms of Wind will enſue.

If the Moon in the Third Day after her Change, or Three Days before her Full, or in the Midſt of the Quarter, be found of pure Light, nothing compaſſing her, the Ends direct up, ſhe promiſeth Fair Weather; but bent to Red Colour, provoketh Winds, as aforeſaid. The Moon ſomewhat Black or Thick, provoketh Rain. When the Moon's Horns are blunt at its Riſing, Three Days after the Change, it denotes rainy Weather for that Quarter; but the other Quarter ſeaſonable Weather: Hence obſerve,

As is the Fourth and Fifth Days Weather,
So's that Lunation altogether.

And when the Moon is Five Days old, mark the Tip of her Horns; if they be blunt, it ſignifieth Rain; if ſharp-pointed and pricking upwards, great Winds: If in the Fourth after her Change, ſhe have a Red Circle about her, it ſignifieth Winds and Rain.

III. By the STARS.

THE obſcuring of the ſmaller Stars foreſhews Tempeſts.

When Stars ſeem to ſhoot, Wind comes from that Quarter.

If the Stars appear of much Light, and ſeem to be of more Bigneſs and Blazing than ordinary, it betokeneth great Winds and Moiſture in that Part where they ſeem ſo; and in Winter great Froſts.

When dim Stars appear with long Fiery Tails, it threatneth Winds and great Drought; the more in Number, the greater will be the Effect.

If the Stars ſeem to ſhoot in divers Places, it ſignifieth divers Winds: If in all Places, Wind, Thunder, Lightning, and moſt tempeſtuous Weather.

Stars dull and hardly appearing, or ſeeming Dull and Large, as through Miſts, betoken Rain.

IV. By the SKY and CLOUDS.

IF the Sky be Red in the Morning, it is a ſure Token of Wind or Rain to follow, or both in Squails, *&c.* for the Vapours which cauſe that Redneſs, will ſoon be diſſolv'd.

If a dark Cloud be at Sun-riſing, in which the Sun is ſoon after hid; it will diſſolve it, and Rain will ſoon follow.

If a Cloud appear, and afterwards Vapours are ſeen to aſcend up to it, it portends Rain.

If Miſts come down from the Hills, or deſcend from the Sky, and ſettle in the Vallies, it promiſeth Fair and Hot Weather: Alſo Miſts aſcending in the Evening from the Earth or Water, ſhew a Hot Day to follow.

Small ſcattering Clouds in the S.W. that fly high, and lie as it were in Ridges, and ſeem to move, engender Winds, and often produce Whirlwinds.

A haſty Shower of Rain falling, when the Wind has rag'd ſome Hours, ſoon allays it: If a Storm riſe with the Sun, at going down of the Sun it will ſoon decline, and about Midnight ceaſe. If the Water ruckles much, and frequent Bubbles ariſe, the Storm is of a ſhort Continuance.

Black Clouds flying from the Eaſt, ſignifie Rain at Night; if from the Weſt, Rain the next Day: If they fly low, and appear to ſettle upon the Tops of Hills, it is a Sign of Cold Weather: If they be full-charg'd, and appear White, like Towers, Hail is at hand. If White Clouds appear in Winter, Two or Three Days together, at Sun-riſing, it is a Sign of Cold and Snow; but Black Clouds ſignifie Rain. A Red Sky in the Evening, and a Grey Morning, is a Sign of a Fair Day. Miſts falling of a Morning, in Spring or Harveſt; alſo Miſts over Ponds or Waters in the Morning, ſhew Rain. If the Clouds fly ſwiftly in the Air, it ſignifies Rain from that part of the Heavens, eſpecially from the North or South. If thick White Clouds, gathered together in many Places, like Flocks or Heaps of Wool, appear; it is a Sign of Rain: But if thick dark Clouds, toward the North or Weſt, near the Earth, preſently Rain; and if like Hills, a little above the Earth, Foul Weather is over. If Miſts deſcend from the Hills, and ſettle in the Vallies, it is a Sign of Fair Hot Weather next Day; or if White Miſts ariſe from the Waters in the Evening.

V. By the RAINBOW.

THE natural Signification of the Rainbow, is to to ſhew Rain paſt or to come.

The Rainbow appearing when it is Fair, is a Sign of Foul Weather; but a Rainbow appearing after Rain, ſignifies Fair Weather: The Greener it appears, the more Rain; the more Wind, if it appears Redder. If it ſhews very Light in the Blue Part, expect Fair Weather. If the Rainbow is ſeen before

before Noon, then the Rain is ſpent; if at One or Two Afternoon, the Rain is near. A Rainbow in the Morning, is a Sign of Wet, (unleſs there be Drought in the Air:) If it appear in the Evening, it is a Sign of Fair Weather, (unleſs the Air abound with Moiſture.) A Rainbow at Night, oppoſite to the Moon, is a Sign of much Small Rain and Wind to follow. A Rainbow after long Rain, is a Sign of Fair Weather, preſently. If Two Rainbows appear together, it is a Sign of Rain within Two or Three Days.

Anſwers to the Queſtions in NAVIGATION, *propos'd at the Beginning of this Appendix.*

In Plain Sailing.

QUEST. I Courſe *S.W.* b. *S.* $\frac{1}{2}$ *W.* neareſt Diſt. 91$\frac{1}{4}$ l. *x.* Lat. 68$\frac{3}{4}$ l.
Queſt. II. Courſe *S.E.* $\frac{1}{4}$ *E.* Diſt. 370 l. Departure 296 l.
Queſt. III. Courſe *S.* 64° 28′ *W.* Southing 52 m. Weſting 108 m.
Queſt. IV. Diſt. 252,1098 l. *x.* Lat. 208,9752 l. Dep. 139,691 l.
Queſt. V. Diſt. 946 m. *x.* Lat. 786 m.
Queſt. VI. Courſe *N.* 53°. 08′. *E. x.* Lat. 360 m. Dep. 480 m.
Queſt. VII. Diſt. 1181 m. *x.* Lat. 452 m. Dep. 1091 m.
Q. VIII. Courſe *S W.* b. *S.* $\frac{1}{4}$ *W.* neareſt *x.* Lat. 122,14 m. Dep. 92,14 m.
Queſt. IX. Diſt. 250 m. *x.* Lat. 200 m. Dep. 150 m.
Queſt. X. Diſt. 840,093 m. *x.* Lat. 640,093 m. Dep. 544,093 m.
Queſt. XI. Courſe *N.E.* b. *N.* $\frac{1}{4}$ *E.* Diſt. 133,333 l. Lat. in 5°. 20′. *N.*
Q. XII. Courſe *S.W.* b. *S.* 1° 21′. Weſterly, Diſt. 516$\frac{1}{2}$ m. Dep. 295$\frac{1}{4}$ m.
Queſt. XIII. Courſe *S.E.* $\frac{1}{4}$ *E.* neareſt Dep. 444 m. *x.* Lat. 333 m.
Queſt. XIV. Courſe *S.W.* b. *S.* 1°. 29′. 44″. Weſterly, Diſt. 801,9 l. Diff. Lat. 656,9 l. Dep. 459,9 l. Lat. in 19°. 56′. *S.*
Queſt. XV. Courſe *N.* 50° 22′. *E.* Diſt. 60 l. Dep. 45,87 l.
Queſt. XVI. Diſt. 96$\frac{1}{4}$ l. Dep. 44$\frac{1}{4}$ l. to and from the Equator.
Queſt. XVII. The Second Ship's Diſt. 665 l. *x.* Lat. and Dep. of each 470 l.
Queſt. XVIII. Each Ship's Diſt. is 665 l. and Dep. 470 l.
Queſt. XIX. 172 Fathom of the Beſt Bower-Cable.
Queſt. XX. Northermoſt Ship's Courſe is *S.* 74°. 19′. *E.* Dep. 712$\frac{1}{2}$ l. The Middlemoſt Ship's Courſe is *S.* 57°. 15′. *E.* Dep. 588 l. The Southermoſt Ship's Courſe is *S.* 30°. 20′. *E.* Dep. 353 l.
Queſt. XXI. The *Revenge* ſailed 47 l. the *Torbay* 71 l. the *Orford*'s Diſt. ſailed is 153 l. her *x.* Lat. 128 l. and the *Cornwall*'s Diſt. was 101 l. her Dep. 56 l.
Queſt. XXII. Firſt Ship's Courſe is *N.* 44°. 14′. *E.* Second Ship's Courſe is *S.* 23°. 16′. *E.* the reſt is obvious.

Queſt.

Queſt. XXIII. Ship's Eaſting from A to B is 27 m. Lat. of the Port B, 45°. 36'. *N.* Courſe from A to B, *N.* 36°. 52'. *E.* Diſt. from B to C, is 60m. and Second Courſe ſteer'd is *S.* 57°. 07'. *E.*

Queſt. XXIV. $\left\{\begin{matrix}37\frac{1}{2}\\30\end{matrix}\right\}$ Miles Diſt. the Ports $\left\{\begin{matrix}A\&B\\A\&C\end{matrix}\right\}$ are aſunder.

$\left\{\begin{matrix}1\\2\end{matrix}\right\}$ Dep. $\left\{\begin{matrix}13,5\text{ m.}\\24\text{ m.}\end{matrix}\right\}$ Courſe from $\left\{\begin{matrix}B\text{ to }C,\ N.\ 36°.\ 18'.\ W.\\C\text{ to }A,\ S.\ 53.\ 07.\ E.\end{matrix}\right.$

Q. XXV. $\left\{\begin{matrix}\text{Diſt.}\\\text{Dep.}\\\text{Courſe}\end{matrix}\right\}$ $\left\{\begin{matrix}\text{from}\\A.\text{to}D.\end{matrix}\right\}$ $\left\{\begin{matrix}30\text{ m.}\\24\text{ m.}\\N.53°.07'.E.\end{matrix}\right\}$ $\left\{\begin{matrix}\text{from}\\D\text{ to }B,\end{matrix}\right\}$ $\left\{\begin{matrix}22,2\text{ m.}\\13,5\text{ m.}\\S.36°.18'\ E\end{matrix}\right.$

Q. XXVI. $\left\{\begin{matrix}\text{Courſe}\\\text{Diſt.}\\\text{Dep.}\end{matrix}\right\}$ $\left\{\begin{matrix}\text{from}\\A\\\text{to C,}\end{matrix}\right\}$ $\left\{\begin{matrix}N.E.\frac{1}{2}E.\\30,2\text{ l.}\\23,8\text{ l.}\end{matrix}\right\}$ $\left\{\begin{matrix}\text{from}\\C\\\text{to B.}\end{matrix}\right\}$ $\left\{\begin{matrix}S.\ 41°.\ 38'.\ E.\\21,7\\14\end{matrix}\right\}$ Leagues.

Q. 27. the Iſles $\left\{\begin{matrix}A\ \&\ C\\A\ \&B\\C\ \&\ B\end{matrix}\right\}$ are diſtant. $\left\{\begin{matrix}38,3\text{ l.}\\31,35\text{ l.}\\19,72\text{ l.}\end{matrix}\right\}$ bears $\left\{\begin{matrix}N.54°.41'.E.\\S.54°.41'.W.\\E.\&W.N.\&S.\end{matrix}\right.$

Queſt. XXVIII. Diſt. 50m. *x.* Lat. 30 m. Dep. 40 m. Courſe *S.* 53°. 07. *W.*

Queſt. XXIX. By the 31ſt Prop. 3d Book of *Euclid*, 'tis prov'd, that an Angle in a Semicircle is a Right Angle: *Ergo*, To what Place ſoever the Ship was blown from A, right before the Wind, and put a-ſhore, the ſame Wind upon the Beam, would carry her to the Port oppoſite, at B.

Queſt. XXX. Courſe to the Port B, is *N.* 70°. 32'. *E.* or near *E.N E.*$\frac{1}{4}$*E.* demonſtrable by *Euclid*, Lib. 3. Prop. 20.

Queſt XXXI. Admits of a like Conſtruction and Solution as Queſtion 22d foregoing.

In Oblique Plain Sailing.

QUEST. I. Courſe *S.* 26°. *W.* Diſtance 116 Leagues.

Queſt. II. *N.* 61°. *E.* the Courſe requir'd.

Queſt. III. *S.* 37°. 58' *W.* Diſtance 6,22 m.

Queſt. IV. *S.* 58°. 46'. *W.* and *N.* 58°. 46'. *E.* Diſtance 9,7 m.

Queſt. V. Firſt Ship's Diſt. 10,45 m. Second's Diſt. 4,65 m. their Bearing is *N.* 37°. 14'. *E.* and *S.* 37°. 14'. *W.*

Queſt. VI. The Head-Lands bear *N.*88°.53'.*E.*and *S.*88°.53'.*W.* neareſt Diſt. 7,95 m. the Eaſtermoſt Head-Land from the Iſland *S.*14°. 30'. *W.* Diſt. 9,15 m. and the Weſtermoſt Head-Land from the Iſland *N.* 32°. 15'. *W.* Diſt. 10,6 m.

Queſt.

Queſt. VII. The Cruiſer muſt ſail *S.* 26°. 43'. *E.* 173,6m. and in 24 H. 48 M. time, he will fall in with the Fleet.

Queſt. VIII. The Buoy bears from the Firſt Head-Land *E.N.E.*$\frac{1}{2}$*E.* Diſt. 45 m. and from the Second Head-Land neareſt *W.S.W.*$\frac{1}{2}$*W.* Diſt. 74 m. the Second Iſle bears from the Second Head-Land, *S.*$\frac{1}{2}$*E.* neareſt 115 m. the Rock bears from the Second Iſland *W.S.W.* Diſt. 54 m. the Firſt Iſle bears from the Rock *W.b.N.*$\frac{1}{4}$*W.* Diſt. 99 m. and the firſt Head-Land bears from the Firſt Iſland *N b.E* $\frac{1}{2}$*E.* 100 m. neareſt.

Queſt. IX. Courſe *N. E.* Diſtance from the *Grand Canary*, 105 m. Lat. ſhe took the Pirate in, was 26°. 45'. *N.*

Queſt. X. She muſt run 13,0655 l. before ſhe Tacks, and and then afterward 7,69037 upon the Second Tack.

Queſt. XI. The Firſt Ship ſail'd 45 l. and the Second 80$\frac{1}{2}$ l.

Queſt. XII. Second Ship's Courſe is *W.S.W.* Firſt Ship's Diſt. 49$\frac{1}{2}$ l.

Queſt. XIII. The Weſtermoſt Ship's Diſt. is 85 l. the Eaſtermoſt Ship's Diſt. 511. and her Courſe is *N N.W.* c°. 12. *N.*

Queſt. XIV. Diſt. on the Firſt Courſe 133 m. on the Second 96 m. her Diſtance from the Firſt Iſland 113 m.

Queſt. XV. The { Northermoſt / Weſtermoſt / Eaſtermoſt } Ship's Courſe { *South.* / *N.E.*b.*N.*$\frac{1}{4}$*E.* / *N.* 67°. *W.* } their Diſt. to the Iſland 45 m.

Queſt. XVI. The Weſtermoſt Ship's Diſt. is 105,1575 l. the Eaſtermoſt 140,195 l. they bear off each other, *E.*$\frac{1}{2}$*N.* and *W.*$\frac{1}{2}$*S.* and they were 2 Days, 22 Hours in ſailing to their ſeveral Ports.

Queſt. XVII. The Ship ſail'd { 45,8103 / 53,0256 / 59,1641 } L. upon the { *N.E.*b.*E.*$\frac{1}{4}$*E.* / *N.W.*$\frac{1}{4}$*W.* / *South* } Courſe.

Queſt. XVIII. The Firſt Ship's Courſe is *N.* 41°. 19'. *W.* Diſt. 299 m. and the Second Ship's Courſe is *N.* 60'. 51 *E.* 461 Miles.

Queſt. XIX. The Firſt Ship's Diſt. is 139 m. and the Second's Diſt. 147 m.

Queſt. XX. She ſailed 119 m. *N.* and 25 m. *S.E.*

Queſt. XXI. Diſt. from the Ship to A, is 75 L. to B, 145. to C, 117 m.

Queſt. XXII. If the Learner pleaſe to Project, he will form the Figure of a *Rhumb Chart:* The Diſtances or Bearings of each Iſland from the Ship (or Center) he may find by the Firſt and Third Caſe of *Oblique Sailing*, in the foregoing Trea-

Treatiſe; to which I refer him, and for want of room here omit the Anſwer, and leave it to his own Induſtry.

Queſt. XXIII. Courſe *S.* 15°. 25'. *W.* Diſt. 57,035 l. The other Courſe is *S.* 53°. 21'. *W.* and the Diſtance 92,139 l.

Queſt. XXIV Diſtance from { the *Lizard* / *Plimouth* / *Start-Point* } to the *Edyſtone*, is { 53,04 / 14,333 / 17,36 } M.

Laſtly, I judge it needleſs to inſert the Anſwers to the ſeveral *Traverſes*; ſince they are ſo eaſie as to their Projection and Calculation, to him that underſtands what hath been taught in Traverſe in the 78 and following Pages of this Treatiſe: And having already exceeded the deſign'd Limits of this Book, thro' a hearty Deſire to omit nothing that may make the Novice a compleat Navigator, or Sea-Artiſt; To whom, and the Courteous Reader, I wiſh Succeſs in their Study of all Laudable Arts that give Glory to our Nation, by Land or Sea.

Vive, vale: Siquid noviſti rectius iſtis, Candidus, imperti,
Si non, his utere mecum.

FINIS.